EXHIBIT B

In the United States District Court
For the Eastern District of Texas
Tyler Division

Halliburton Energy Services Inc., Plaintiff	§	**Civil Action: 06:05cv155**
	§	
	§	**(Jury Demand)**
v.	§	
	§	**Judge Leonard Davis**
M-I LLC, Defendant	§	

Expert Report of Dr. Ronald K. Clark

1. Introduction

1.1. Purpose and Scope

I have been retained by counsel for Halliburton Energy Services Inc. ("Halliburton") to provide expert analysis and testimony in the above-styled cause with respect to the construction of claims in U.S. Patent Number 6,887,832.[1] This report reflects my opinions regarding the proper interpretation of the disputed terms contained in those claims.

I anticipate testifying on some or all of the topics addressed by this report. In addition, if, prior to or at trial any other expert offers an opinion in my area of competence with which I disagree or upon which I have an opinion, I anticipate that I may comment on that opinion. In the course of that testimony, I may use some or all of the exhibits referenced by this report. Further, I may also use other demonstrative exhibits, summaries, or the exhibits that are not yet prepared to further illustrate my opinions. I understand that prior to trial, such exhibits would be exchanged with all other parties at a mutually agreeable time.

In the event of subsequent developments, including the availability of additional evidence, that may have a bearing on the opinions I have expressed in this report, I expect that I may supplement this report to take those developments into consideration or otherwise consider for the purpose of testifying at trial.

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[1] I will use the shorthand "'832" when referring to this patent. When I am referring to specific parts of the '832 patent, I will use the shorthand "Ccc:Lll," where "cc" and "ll" refer respectively

I am being compensated for my time in preparing this report and testifying about matters related to its substance at my usual and customary billing rate of $350.00 and am being reimbursed for my expenses. None of my compensation is based on the outcome of this lawsuit.

1.2. Background and Qualifications

I received a bachelor's degree in Chemistry from the University of California at Riverside in 1963, I received my doctorate in Physical Chemistry from the University of California at Riverside in 1966, and I did my post-doctoral work at Cornell University from 1966 to 1967. I was employed by Shell E&P Technology Company (formerly known as Shell Development) from 1967 until my retirement as a senior staff research scientist in 1996. During my employment with Shell, I initially specialized in enhanced oil recovery research (1967-1971) and was then assigned to the drilling research group specializing in drilling fluids (1971-1996). Since then I have been a private consultant under the name RK Clark Fluid Technology, providing technical consulting services to numerous companies on topics relating to drilling fluids.

From 1974 until 1984, I served as Shell's alternate voting member on the American Petroleum Institute's Committee on the Standardization of Drilling Fluid Materials. From 1985 until 1995 I was Shell's voting member and chaired the Committee from 1987 to 1990. This Committee sets specifications for drilling fluids materials whenever deemed necessary and standardizes

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to column numbers and line numbers in the patent.

procedures for testing drilling fluids. These specifications and standards are recognized and used worldwide.

I am currently a member of the Society of Petroleum Engineers (SPE), an organization whose mission is the dissemination of knowledge and information for the exploration and production industry throughout the world. I served on the SPE Drilling Program Committee from 1986 through 1988 and was chairman of this committee in 1988. I was the chair or co-chair of two drilling fluids related forums that the SPE sponsors. These weeklong meetings are attended by a selected group of recognized experts in the field who come from many different countries.

My *curriculum vitae* is attached to this report as Exhibit A and provides a more complete description of my education, background, qualifications, publications, and experience as an expert.

1.3. Basis for Report

In preparing this report, I have relied upon a variety of materials that have been provided to me. A list of these materials is attached to this report as Exhibit B. In addition to my review of these materials, in preparing this report, I have relied on the experience and information that I have obtained in nearly thirty-five years of work and research in the oil drilling industry.

I have been advised by counsel for Halliburton that in claim construction, courts examine the patent's intrinsic evidence to define the patented invention's scope, and that this intrinsic evidence includes the claims themselves, the specification, and the prosecution history. I have been further

advised that courts give claim terms their ordinary and accustomed meaning as understood by one of ordinary skill in the art at the time of the invention, that technical dictionaries and treatises may help a court understand the underlying technology and the manner in which one skilled in the art might use claim terms. As such, in forming the opinions set forth in this report, I have directed my attention to the intrinsic evidence and have only looked to extrinsic evidence as necessary to determine the meanings of claim terms as would be understood by one of ordinary skill in the art in June of 2002.

2. Opinion as to a Person of Ordinary Skill in the Art

The '832 patent describes its fragile gel drilling fluid in terms of:

- The chemistry of the drilling fluid. *E.g.*, C9:L22-C10:L52.
- The measurements of the drilling fluid properties (both in the laboratory and in the field. *E.g.,* C11:L17-L57.
- The variations on the drilling fluid formulation. *E.g.,* C11:L66-C12:L13:L31.
- The effects that variations on the drilling fluid formulation will have on its performance. *E.g.,* C13:L32-L65.

In order to have a sufficient understanding of the '832 patent, including the chemistry and instrumentation required to formulate and evaluate the fragile gel drilling fluid it discloses, it is my opinion that a person of ordinary skill in the art would have, at a minimum, a bachelor's degree in chemistry or chemical engineering, and at least five years actual experience in the formulation and use in the field of drilling fluids, or sufficient formal or

informal training such that the person could appreciate the purposes of and variations on the proportions of the components of drilling fluids, including invert emulsion bases, emulsifiers, thinners, weighting agents and other common additives for controlling the filtration and rheological properties of the drilling fluid, and would have a working knowledge of the proper use, both in the field and in the laboratory, of the instrumentation used for obtaining measurements of drilling fluid properties, the interpretation of those measurements, and the application of those measurements to an active drilling operation.

3. Technical Background as Would be Understood by a Person of Ordinary Skill in the Art as of June 2002[2]

3.1. Overview of Oil Well Drilling

In order to understand the meanings of terms and phrases used in a patent about drilling fluids, the court must have a working knowledge of the process of drilling an oil well and the use of drilling fluids in that process.

The process begins when drilling crew prepares the site for the drilling operation—this might involve digging a "waste pit" for disposing of the cuttings, digging a "cellar" for providing a work area around the actual hole, drilling or driving a "conductor pipe" into the ground, and then moving in the drilling rig.[3]

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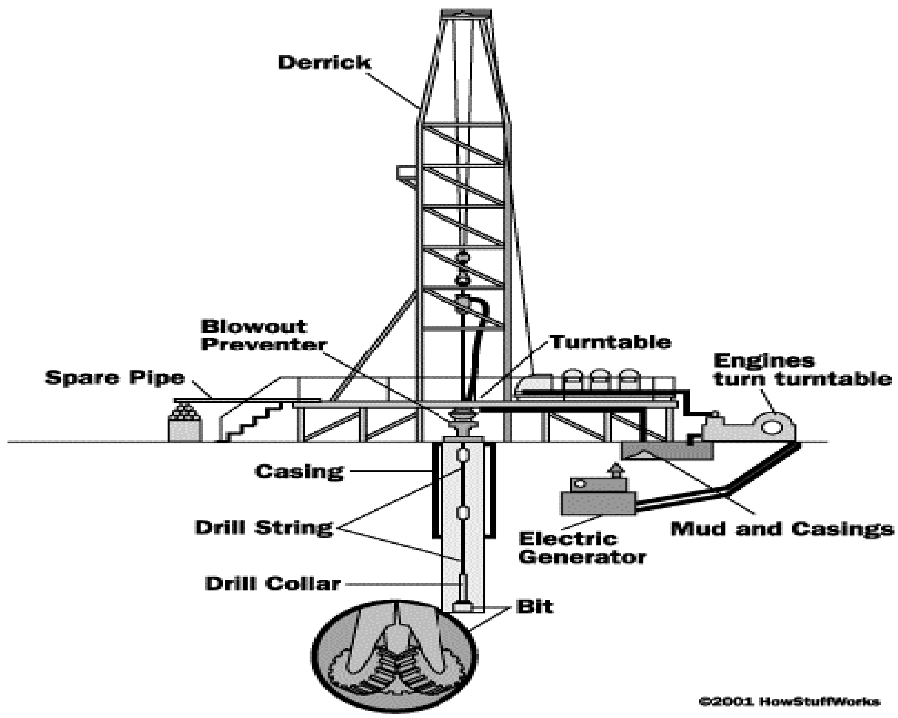
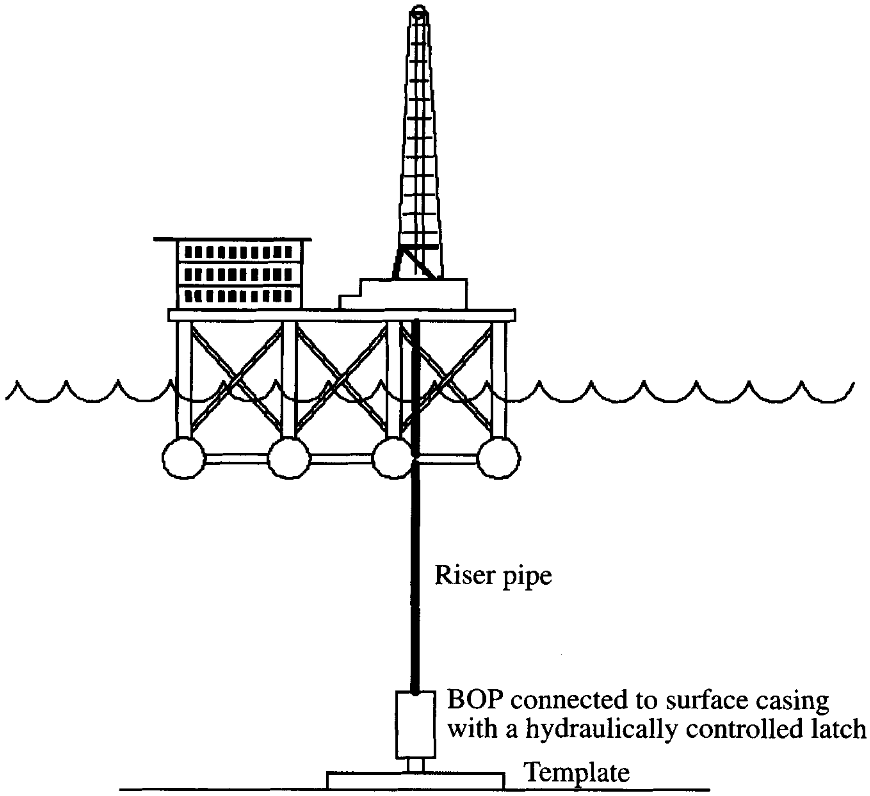
[2] Where appropriate, this Report may cite to specific references. This section, however, is based on my extensive experience in the field of drilling and drilling fluid technologies. The information presented can be found in any number of treatises, reference books, articles, papers, training manuals, and the like. A list of a sampling of these common references can be provided upon request.

[3] For an offshore operation, this may involve securing a "template" to the seabed, lowering a drilling assembly down from the drilling rig through a hole in the template, drilling a hole, and inserting the conductor pipe.

The most visible portion of the rig is the “derrick” which holds the drilling apparatus, and includes a hoisting system that can lift and hold the drill pipe when needed during the drilling operation. The drilling is performed by a “drill bit” that is attached to the “drill string” consisting of “joints” of “drill pipe” connected together, along with “drill collars,” which are thick-walled segments of pipe that add weight to the drill string. The figures below show the major components of the drilling rig:

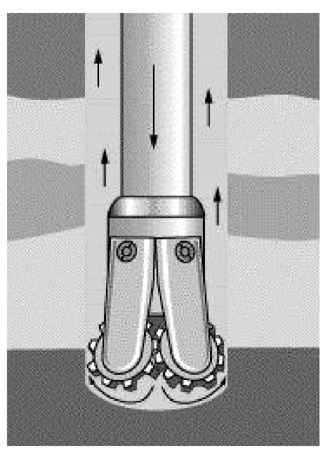




Drilling operators choose from a number of different types of drill bits depending on the type of rock in the formation.

Roller cone bits can handle rough drilling conditions and are relatively low in cost, however with time, the "teeth" on the bit will become dull and the bearings rotating the cones will wear out. Fixed cutter bits use synthetic diamond disks mounted on tungsten carbide studs (often called "PDC" bits), cut through hard or soft materials very quickly, lack the moving parts that would wear out on a roller cone bit, however, they are very costly. Synthetic diamond bits are particularly useful when used in combination with invert emulsion drilling fluids.

Pumps move "drilling fluid" (or more commonly, "mud") from the "mud pit," which is a reservoir for holding the drilling fluid, down through the drill string and drill bit, and then back up through the "borehole" (or "wellbore" or "annulus"), and back to the mud pit. Under certain circumstances, for example, when it is necessary to clean out the wellbore, the drilling operator may continue to pump mud even while the drill bit is not rotating. However, the drilling operator will never rotate the drill bit without mud circulating through the wellbore.

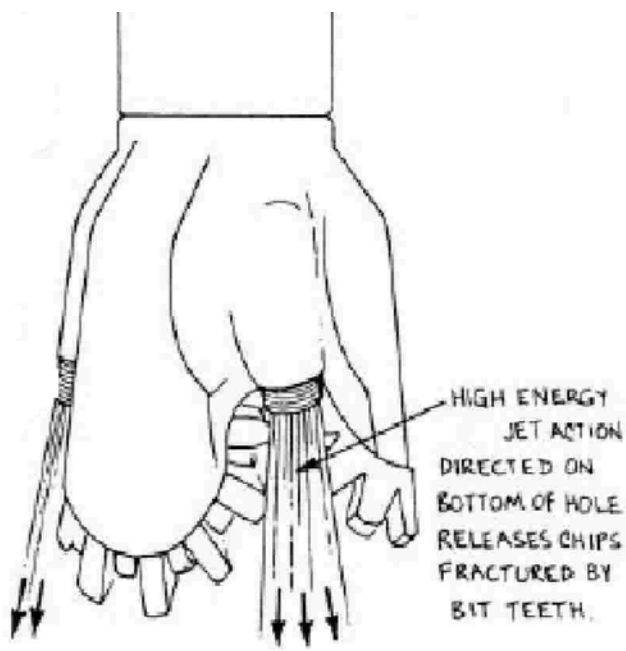


As the drill bit turns, it breaks away the rock formation[4] beneath it through a violent combination of forces that, depending on the type of drill bit, may include tearing, crushing, gouging, shearing, plowing, and/or grinding actions. This action generates a great deal of heat—this shows one of the many purposes of mud:

a. Mud helps lubricate and cool the drill bit.

The pump moves the mud through small jets in the drill bit at sufficient pressure to push the "cuttings" away from the bottom of the hole. As the drill bit breaks away at the rock, the cuttings must be moved away from the drill bit so that it can continue drilling through the formation—this shows another of the purposes of mud:

b. Mud washes the cuttings away from the drill bit.

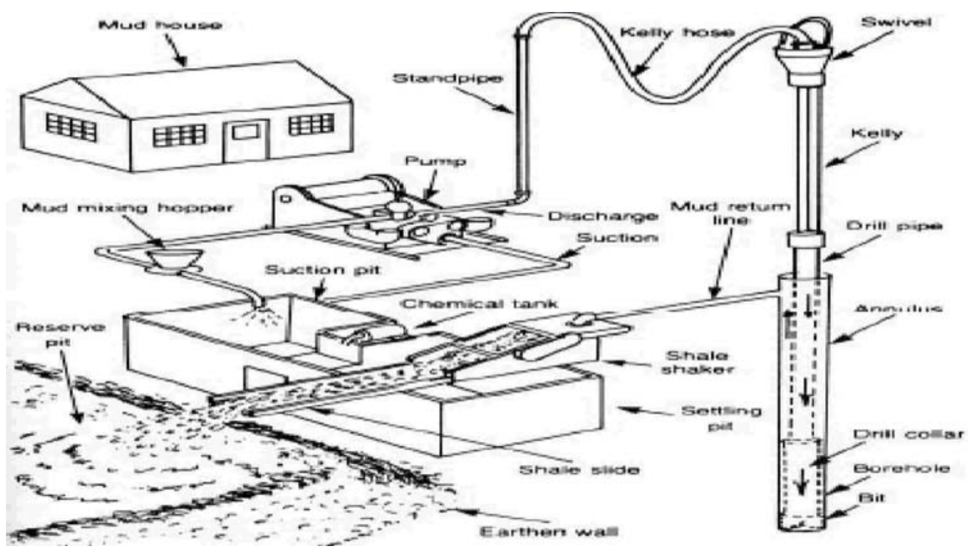


[4] The formation may be composed of shales (layers of clay minerals), sandstones (mostly quartz with trace minerals), carbonates (fossilized skeletons and mineral grains of calcite), salts, as

The cuttings must then be transported up to the surface where they can be disposed—this shows another of the purposes of mud:

c. Mud transports drill cuttings out of the well.

As the mud washes the cuttings away from the drill bit, the mud carries the cuttings back up the wellbore to the surface. After the mud returns to the surface, it passes through a series of mechanical equipment, such as “shaker screens,” “hydrocyclones,” and/or “decanting centrifuges” to remove the cuttings, and then returns to the mud pit for adjustment of its properties and reuse.



At the surface, the well operator can examine the materials coming up from the bottom of the well—this shows another of the purposes of mud:

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well as combinations of each.

d. *Mud carries cuttings to the surface where their properties can be analyzed.*

By examining the cuttings, as well as other materials coming up from the bottom of the well (such as fluids and gases), and by recording and analyzing drilling parameters (pressure, rotary speed, temperature, and the like), the operator can make changes to the drilling operation.

As the drill bit bores deeper and deeper, the operator must insert sections of drill pipe into the drill string. This involves stopping the circulation of the mud, disconnecting the drill string suspending the drill string and then screwing a new section of drill pipe into the drill string. During this operation, the mud does not circulate, and the cuttings suspended in the mud will have the tendency to settle—this shows another of the purposes of mud:

e. *Mud must hold the cuttings in suspension while the circulation has been halted.*

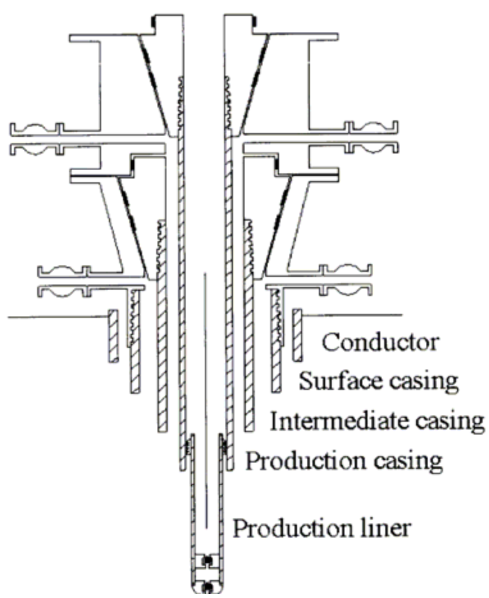
However, the ability of the fluid to hold the cuttings in suspension (its “gel strength”) should not be so great that too much pressure is required to resume the flow of the mud once drilling has restarted—the high pressure imposed on the wellbore could fracture the formation.

When the drill bit has reached a certain depth, the operator will need to insert “casing” into the wellbore; casing is a large-diameter pipe that helps prevent the formation wall from caving into the wellbore, isolates different formations to prevent the flow or cross-flow of formation fluids, and provides a means of maintaining control of formation fluids and pressure as the well is

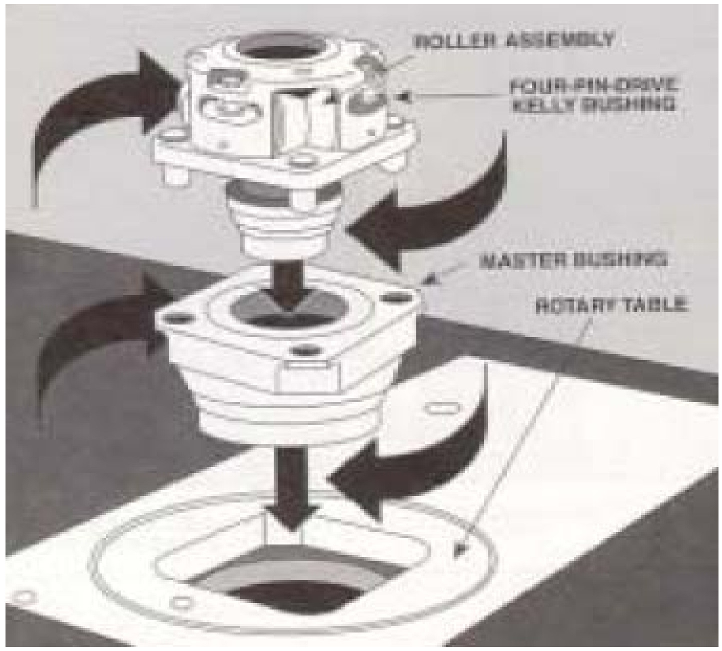
drilled deeper. To case the wellbore, the operator first must remove, or “trip out,” the drill string. The operator then inserts multiple sections of casing into the wellbore, using “centralizers” and other devices to maintain a uniform gap between the casing and the wellbore. The operator then pumps cement into the inside of the casing, and uses mud to push the cement down through the casing, out the bottom of the lowest segment of casing, and then back up into the gap between the casing wall and the wellbore. This shows another of the purposes of mud:

f. *Mud must push cement through the casing.*

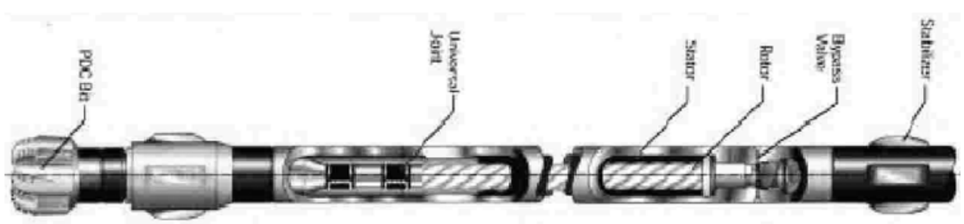
Once the cement has hardened, the operator may continue drilling the well. The operator may repeat the casing operation multiple times during the course of drilling the well; to allow the insertion of the drill string and additional casing, the wellbore will necessarily get narrower as the well gets deeper and deeper.



For most operations, a motor at the top of the drill string rotates the entire drill string, including the drill bit:



Sometimes, however, it is necessary to change the direction of the well, for example, because the rig cannot be positioned directly above the reservoir or because of the geology of the formation. For these operations, the operator may choose to use a “downhole motor and bent sub” or a “downhole stearable motor.”



Instead of rotating the entire drill string to turn the bit, the hydraulic pressure of the mud pumping through the drill string turns the drill bit,

allowing deviations in the direction of the well. This shows another of the purposes of mud:

g. Mud must turn the drill bit when necessary.

As the depth of the well increases, the fluids and gases in the formation are under a greater and greater pressure because of the fluids, gases, and formations above them. If the well passes through a formation with an abnormally high pressure, the mud could be pushed back up the well (a “kick”), which could cause a “blowout” of the well if not controlled. However, if the pressure exerted by the formation is abnormally lower than the mud pressure, then mud could fracture the formation and be lost. [5] This shows another of the purposes of mud:

h. Mud must exert sufficient downward pressure to counter the pressures of the formation without an unacceptable loss of fluid into the formation.

When the well has reached its final depth and has been cased, the operator lowers a small-diameter pipe into the hole as a conduit for oil and gas to flow up the well, the casing is sealed above the production level, and a multi-valve structure called a “Christmas tree” to the top of the tubing and cement it to the top of the casing. The operator lowers a “perforating gun” down to the production level of the well, and creates small holes in the casing.

[5] Losses are typically indicated according to the amount or percentage of loss per hour, however, there are no formal classifications for classifying fluid loss: a “seepage” might mean a relatively minor loss, a “total” loss might mean that no fluid returned to the surface, with a whole range of losses in between.

To summarize, mud performs numerous functions in the drilling of an oil well:

- *Mud helps lubricate and cool the drill bit.*
- *Mud washes the cuttings away from the drill bit.*
- *Mud transports drill cuttings out of the well.*
- *Mud carries cuttings to the surface where their properties can be analyzed.*
- *Mud must hold the cuttings in suspension while the circulation has been halted.*
- *Mud must push cement through the casing.*
- *Mud must turn the drill bit when necessary.*
- *Mud must exert sufficient downward pressure to counter the pressures of the formation without an unacceptable loss of fluid into the formation.*

In order to perform all of the functions, the mud must have characteristics that are seemingly mutually exclusive—the selection of mud formulation then represents a compromise to balance all of the competing needs, including costs. The following section discusses various physical, chemical, and rheological[6] properties of mud.

[6] Rheology is the science of the deformation and flow of matter.

3.2. Drilling Fluid Properties

3.2.1. *Physical Properties*

The density (or "weight") of the mud controls how much pressure the fluid will exert on the formation. Certain "weighting materials," such as barite, can be added to the mud to increase its density. However, higher densities are often accompanied by higher solids content and this will affect the rheology of the fluid (see discussion below). Further, the higher solids content can cause abrasive wear and tear on the fluid circulating system. In high-angle and deviated wells, the weighting materials may settle unevenly to the low side of the borehole causing "sag" when the fluid isn't circulating. *E.g.,* Zamora, Mario; Jefferson, Dan; *Controlling Barite Sag Can Reduce Drilling Problems*, Oil & Gas Journal, Feb. 14, 1994.

In permeable formations, the drilling fluid may form a "filter cake" on the wall of the annulus. Depending on the type of fluid used and the composition of the formation, the filter cake may be thin but impermeable to loss of fluid into the formation (desirable) or it may be thick and sticky and affect the flow of fluid (undesirable).[7]

3.2.2. *Chemical Properties*

Mud can be divided into a few major categories, water-based, oil-based, and combinations of oil and water. In a water-based fluid, the water is present

[7] Mud may seep into the formation because of excessive downhole pressures, or simply because the formation is highly permeable or contains naturally-occurring faults and fractures. The loss of mud can be costly not only in terms of the direct cost of the mud itself but in terms of the added operational expenses incurred in formations where fluid is being lost.

as the continuous phase[8] and in an oil-based fluid, oil is the continuous phase. An "invert oil emulsion" fluid is an oil-based fluid that has more than 5 percent water by volume of the liquid phase.

Because many oil reservoirs are found in shale formations, a water-based fluid may react with the shale, hydrating the formation, and causing it to swell and become soft, making it difficult to drill. Further, water-based fluids may cause corrosion to the steel tools, drill pipe, and casing downhole. In addition, the water in the fluid may react with the hydrogen sulfide present in some wells, causing further corrosion to the steel in the well.

One way to avoid the problems associated with a water-based mud is to use an oil-based drilling fluid such as a 100% oil-based mud or an invert emulsion. An invert emulsion is composed of at least two fluids where one of the fluids is an oil as the continuous phase of the emulsion, and the other fluid is typically water (or a saline solution) comprising the dispersed or internal phase of the emulsion. Invert emulsion muds have traditionally been applied in high temperature wells (greater than about 300° F), wells in which high concentrations of acid gases such as hydrogen sulfide and carbon dioxide are encountered, for drilling sections of soluble salts, in high angle wells where excellent lubricity is needed, and wells in which water-sensitive formations (shales) are encountered. Historically the use of invert emulsion fluids was restricted to onshore use only because the base oil used was diesel—cuttings

[8] The "continuous phase" is the main component of the system by volume.

generated in offshore operations when using inverts formulated with diesel oil could not be discharged on site for environmental reasons. *E.g.,* Boyd, P.A.; Whitfill, D.L.; Carter, T.S.; and Allamon, J.P.; *New Base Oil Used in Low-Toxicity Oil Muds*, Journal of Petroleum Technology, January (1985.) However, in the 1980s, a number of highly refined petroleum oils known as mineral oils were introduced. Mineral oils were much less toxic in the marine environment than diesel oil and cuttings coated with a mineral oil invert could be discharged at the well site in some parts of the world. *Id.* However, eventually discharge regulations changed and disallowed the discharge of cuttings containing mineral oils everywhere. Clark, R.K.; *Impact of Environmental Regulations on Drilling Fluid Technology*, Journal of Petroleum Technology, September 1994.

In the 1990s, drilling fluid companies devised new types of muds that used synthetic oils such as palm oil derived esters and food-grade paraffins as their base—these are the so-called "synthetic inverts." As environmental regulations tightened and some of these bases fell out of favor, "second generation" bases, including internal olefins, esters, linear alpha-olefins, poly alpha-olefins, and linear paraffins were developed. *E.g.,* Friedheim, J.E.; Conn, H.L.; *Second Generation Synthetic Fluids in the North Sea: Are They Better?,* SPE 35061 (1996). These second-generation synthetic-based drilling fluids share the desirable drilling properties of oil-based and first generation synthetic-based fluids but are less disruptive on the environment. *Id*; Neff, J.M., McKelvie, S., Ayers, R.C., *Environmental Impacts of Synthetic Based Drilling Fluids*, U.S. Dept. of Interior (2000) The low toxicity of the synthetics and the

muds formulated with them has allowed their use in offshore drilling as the cuttings can be discharged provided certain environmental tests are satisfied. *Id*; 40 C.F.R. §435.13.

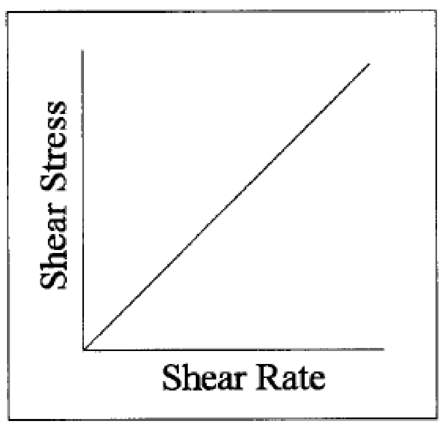
Invert emulsion muds are traditionally made up of the following components:

- A base oil, either of petroleum origin or a synthetic oil (the continuous phase).
- A saline solution dispersed in the base oil (the discontinuous phase).
- One or more emulsifiers to maintain a stable emulsion.
- A source of alkalinity, normally lime, to activate the one or more of the emulsifiers.
- One or more viscosifiers, usually a clay that has been treated to provide viscosity in an non-aqueous fluid (an organophilic clay), or an oil soluble polymer.
- A wetting agent (may also be one of the emulsifiers) to keep the surface of added or incorporated solids in an oil-wet state.
- A fluid loss additive, typically an organophilic lignite or a polymer
- A weighting agent, usually barite for increasing or maintaining the density of the fluid.

E.g., Boyd et al., *supra.* Other additives may be used as needed, for example, thinners (to lower the viscosity of the fluid) and rheology modifiers (for adjusting the rheological characteristics of the fluid).

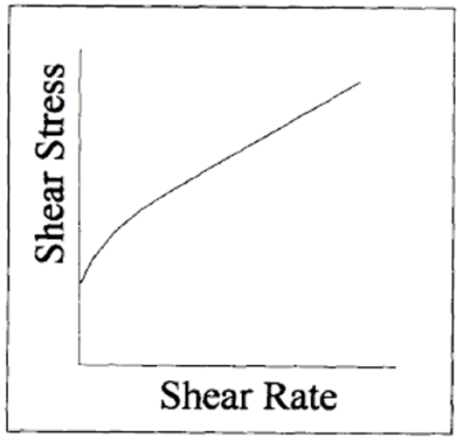
3.2.3. *Rheological Properties*

The viscosity of a drilling fluid represents the fluid's internal resistance to flow—the higher the viscosity of a fluid, the greater its resistance to flow. Viscosity is measured as the ratio of the amount of force ("shear stress") required to move a section of fluid ("shear rate") relative to a stationary section of fluid. For a "Newtonian fluid," such as water or oil, the shear stress is proportional to the shear rate; for example, doubling the shear rate will double the shear stress. As soon as the pressure is applied to the fluid, it begins to move; that is, the fluid "yields" to the pressure immediately. This can be shown graphically as:



For "non-Newtonian fluids," the fluid may require an initial force in order to put the fluid into motion; that is, it will have a non-zero "yield point." Further, once the fluid has begun moving, the viscosity will change non-linearly with the shear rate. The viscosity of a "dilatent" fluid will increase as the shear rate increases, while the viscosity of a shear-thinning fluid, for

example a "Hershel-Buckley"[9] fluid, will decrease as the shear rate increases. This can be shown graphically as:



The viscosity of non-Newtonian fluids may vary with the passage of time. A fluid at rest that becomes more viscous with time is termed "thixotropic." if the shear rate drops to zero a thixotropic fluid will form a "gel," which is effectively a fluid with the characteristics of a solid. The "gel strength" of a thixotropic fluid is typically measured in terms of its strength after rest periods of ten seconds and ten minutes, and may also include a thirty-minute measurement. *API RP 13B-2: Standard Procedure for Field Testing Oil-based Drilling Fluids*, 3rd Ed., API (1998). In the 1990s, it was recognized that a thixotropic material that moves quickly between the gel phase and the liquid phase would be an advantageous characteristic of drilling fluid. *E.g.*, Burba, J.L.; Tehan, W.F.; Hamilton, F.D.; Holman, W.E.; Porzucek, C., Christenson, C.P.; McKenzie, J., *Field Evaluations Confirm Superior Benefits of MMLHC Fluid*

[9] Two other mathematical models for describing the rheology of a non-Newtonian fluid are the "Bingham plastic" model and the "pseudoplastic" model. These models are less useful for describing the fluid performance at low shear rates.

System on Hole Cleaning, Borehole Stability, and Rate of Penetration," SPE 19956 (1990) Numerous publications going back thirty years have referred to such thixotropic materials as "fragile gels." *E.g.,* Samuels, A., *H_2S Need Not Be Deadly, Dangerous, Destructive,* SPE 5202 (1974).

Temperature can affect the viscosity of both Newtonian and non-Newtonian fluids—generally, as the temperature decreases, the viscosity increases, and as the temperature increases, the viscosity decreases. This is particularly relevant when dealing with mud because of the differences in temperatures along the length of the drill string (especially in deep water operations where the water temperature can approach the freezing point near the seafloor)—a mud should optimally not exhibit dramatic changes in yield points when measured at different temperatures. This is commonly referred to as a "flat rheology," meaning that the yield point, when graphed as a function of temperature, will result in a relatively flat line between common testing temperatures (for example, 40-120 degrees Fahrenheit) at a fixed pressure.

Pressure also affects the viscosity of a fluid—as the pressure increases, the viscosity increases. This too is particularly relevant when dealing with mud, since downhole the mud will be exposed to pressures from the formation, from the circulation of mud, and from the weight of thousands of feet of mud filling the wellbore. In well drilling operational terms, the shear rate is a function of the flow velocity of the drilling fluid through the drill pipe or the annulus between the pipe and the wellbore. The shear stress is a function of the shear rate and is related to the pressure required to maintain the flow. The pressures

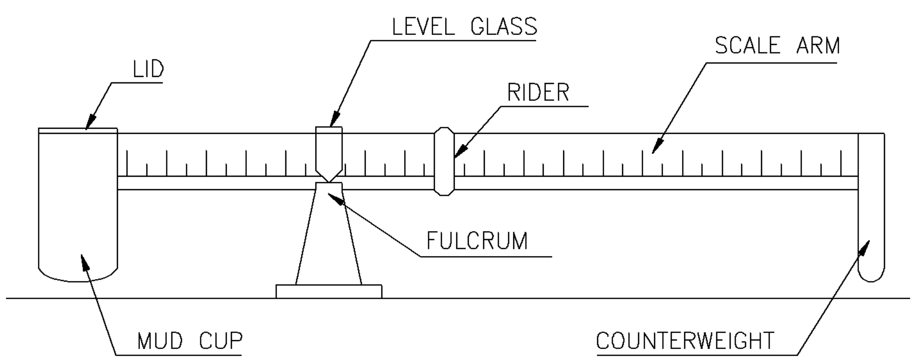
required to maintain the flow of fluids through pipes and annuli are called "friction losses." The minimization of the friction losses is a key factor in the design and maintenance of drilling fluids. Raising and lowering the drill pipe or casing in the absence of circulation can also cause changes in the fluid pressure downhole due to fluid displacement. Such a change is called a surge if the pipe or casing is being lowered or a swab if the pipe is being raised.

As noted below, some viscometers can be configured to test the sample under the pressures and temperatures that might be found downhole.

3.3. Measurement of Drilling Fluid Properties

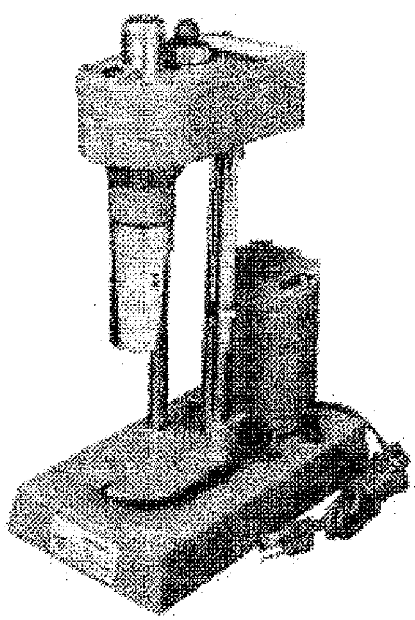
Some of the characteristics of drilling fluids, and of the additives present in the drilling fluids, can be measured by laboratory instrumentation. However, because the behavior of the drilling fluid can vary according to temperature, pressure, and the presence of cuttings, fluids, gases, and other contaminates found in the well, certain characteristics can only be measured in the field. *See generally API RP 13B-2.*.

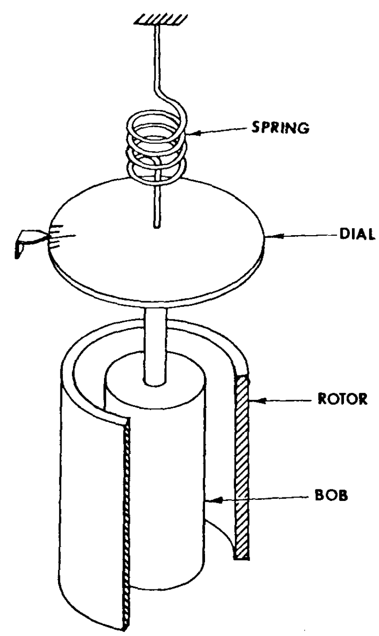
Drilling fluid density is measured in the field at the surface by means of a "mud balance." *API RP 13B-2* §3.1.



The density or mud weight is usually recorded in units of lb/gal, although other units are common outside the United States. Mud densities range from that of water (8.33 lb/gal) to 18 lb/gal or higher. Density measurements are made multiple times during each day the well is being drilled. The density is maintained within a very narrow range (±0.1 lb/gal) as required by the drilling conditions.

Rheological properties can be measured both at the well site and in the laboratory by using in a concentric cylinder viscometer such as the Fann 35. *API RP 13B-2* §4.3. Fann 35 viscometers are configured such that the outer cylinder rotates and the torque is measured on the inner cylinder (commonly referred to as the "bob."





Typically measurements are made at six different rotational speeds from high to low (600 rpm, 300 rpm, 200 rpm, 100 rpm, 6 rpm, and 3 rpm). The fluid is maintained at a constant temperature during these measurements.

This temperature will vary depending on the drilling operation but is usually 120° F. Measurements may be made at more than one temperature such as at 40° F, if a deepwater well (the temperature at the seafloor) is being drilled or at 150° F if downhole temperatures are high.[10]

The "plastic viscosity" (PV) is determined by subtracting the 300 rpm reading from the 600 rpm reading; if the fluid was Newtonian, this would be the viscosity for all shear rates (or rotational speeds). The "yield point" (YP) is determined by subtracting the plastic viscosity from the 300-rpm reading. In the case of a Newtonian fluid, the yield point is zero.

The gel strength, which as noted above in §3.2.3, indicates the drilling fluid's capacity for hold cuttings and weighting material in suspension, can be described as a function of the stress required to initiate fluid movement after a period of rest, which can be measured with a rotational viscometer such as the Fann 35. *API RP 13B-2* §2. Typically a gel strength is measured at intervals of rest of 10 seconds and 10 minutes and often at 30 minutes using, for instance, the standard 3 RPM (Fann 35) or other speed-appropriate for the given instrumentation, as would be readily be apparent by observing the instrument measurements and the movement of the fluid. *API RP 13B-2* §4.3.

The Fann-35 viscometer is less accurate at low speeds, especially where the material being measured exhibits non-Newtonian behavior; this has led to development of other viscometer designs. *E.g.,* Robinson, G. and Jachnik R.,

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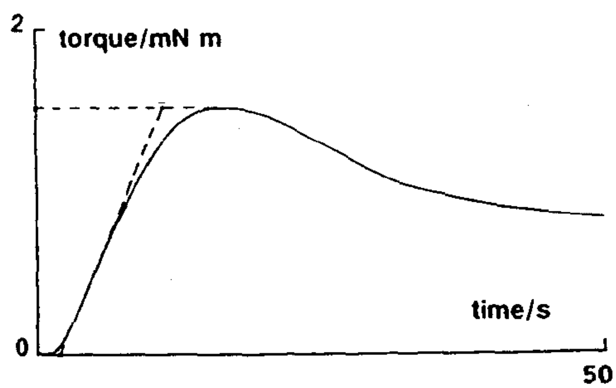
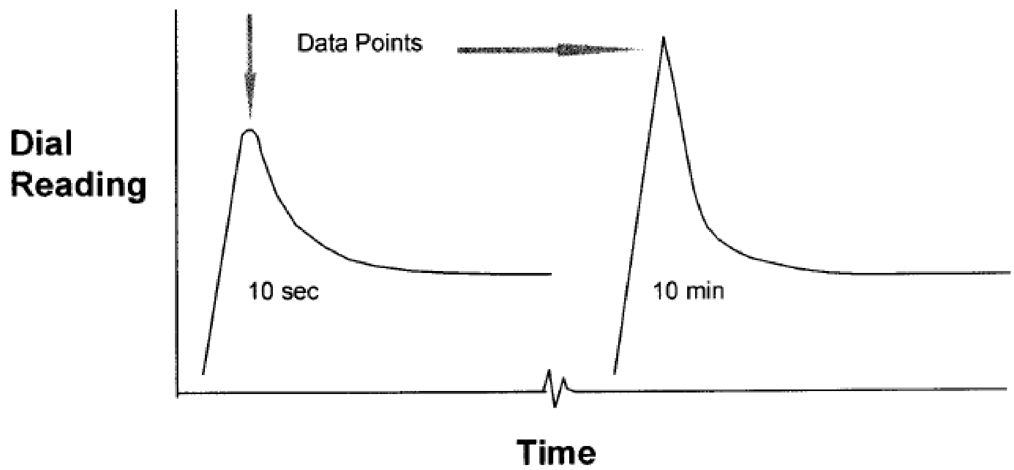
[10] The Fann 75 can test fluids under extreme pressure (up to 20,000 psi) and temperature ranges (up to 500 degrees Fahrenheit).

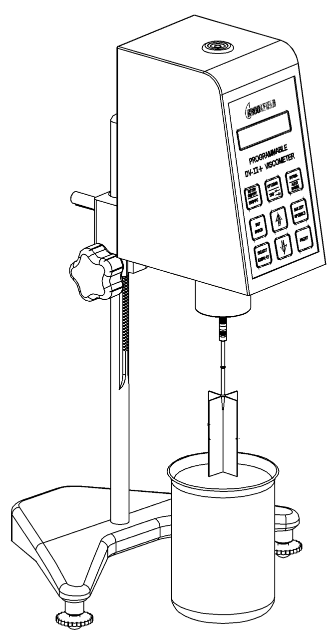
Novel Viscometer for Improved Drilling Fluid Characterization, AADE Drilling Fluids Conference (1996); Saasen, A; Marken, C; Sterri, Njil; Jakobsen, J., *Monitoring of Barite Sag Important in Deviated Drilling*, Oil & Gas Journal, (August 26, 1991). One way to increase the sensitivity of the viscometer is through the use of a "vane" spindle that minimizes any "slip" of the fluid against the spindle. Alderman, N.J.; Meeten, G.H.; Sherwood, J.D.; *Vane Rheometry of Bentonite Gels*, Journal of Non-Newtonian Fluid Mechanics, Vol. 39 P. 291. This is particularly helpful in measuring the viscosity of non-Newtonian fluids that exhibit thixotropic behavior. The instrument readings, plotted as torque as a function of time, will show an initially high torque reading that drops off as the gels break:



By repeating this experiment after longer and longer periods of rest, the technician can determine whether the gels formed are fragile and break easily and completely.



Another viscometer that is well known in the art is the Brookfield viscometer. Typically, the programmable Brookfield viscometer employs a spindle or vane immersed in a sample of fluid wherein the spindle or vane is rotated and torque measurements are taken. *See Brookfield DV-II+ Programmable Viscometer Operating Instructions,* Brookfield Engineering Laboratories.



This viscometer is more sensitive and accurate than the Fann 35 and is particularly useful for measuring viscosity at low shear rates. *Press Release: New Vane Spindles from Brookfield*, Brookfield Engineering Laboratories (3/12/02). The increased surface area of the vane allows for more sensitive readings and facilitates consistent measurements. *SSV Vane Standard Spindle Set Assembly & Operating Instructions*, Brookfield Engineering Laboratories.

A typical Brookfield test begins by mixing the fluid at a moderate speed such that the fluid is homogeneous and at uniform temperature. Once this occurs, the rotation of the vane is stopped and the fluid is allowed to rest for a length of time appropriate for the test.[11] Rotation is then initiated at a low speed and the torque is periodically measured until the torque stops decreasing. Frequently, the torque measurements are plotted as a function of time. For fluids with gels that are slow to break, the curve will gradually decline from its peak to its final reading; for fluids with gels that break easily, the curve will be sharp, shaped like an "L." For distinguishing gels that break quickly from those that break slowly, the specific test procedure (vane geometry, temperature, and speed) and numeric results are unimportant, provided that the procedure is consistent from test to test. For drilling fluids, the higher the peak torque reading, the better the fluid will be at suspending cuttings and weighting materials. The lower the final reading, the better the fluid will be at circulating through the system.

[11] Typically 10 seconds initially, followed by another test at 10 minutes, and another at 30 minutes.

The Brookfield viscometer is also more useful than the Fann 35 for conducting a "relaxation test." *E.g.*, Bloodworth, B.R.; Keely, G.J.; Clark, P.E.; *Mud Relaxation Measurements Help Predict Hole Cleaning Ability*, Oil & Gas Journal (June 1, 1992). In this test, the fluid is sheared and then the motor is turned off. The indicator dial or display is then monitored as a function of time. The results will indicate how quickly the gels form and whether or not the gel strengths lessen with the passage of time. For a drilling fluid, the best results are those that indicate a quick formation of gels that do not break up over time. When shown graphically, the best results would be a curve that falls and levels off quickly.

The rheological measurements, as measured using standard laboratory- and field-testing procedures, like the ones discussed above, are but one indicator of how the mud in question will perform in the well. To a person skilled in the art, the plastic viscosity and yield point measurements have meaning even if they do not describe the rheological properties with absolute precision. *See More Solutions to Sticky Problems,* Brookfield Engineering Labs §1.3. The plastic viscosity and yield point parameters, along with the gel strengths, are controlled within a range that is appropriate for the fluid and the drilling conditions—in the field, the drill operator will look for changes in these measurements and modify the drilling fluid formulation accordingly.

The drilling fluid properties measured at the surface are important but not the only data that need attention—in addition to the tests that can be made on the drilling fluid at the surface (or in a laboratory), there are tests that

assess the properties of the drilling fluid downhole. For obvious reasons, tests that are used to measure density and viscosity at the surface (or in a laboratory) cannot be run thousands of feet down the wellbore. However, by using a tool, first used in the 1990s, known as a “pressure-while-drilling” (“PWD”) instrument, located on the drill string just above the drill bit, the drill operator can measure the pressure downhole. *E.g.,* Hutchison, M. and Rezmer-Cooper, I., *Using Downhole Annular Pressure Measurements to Anticipate Drilling Problems*, SPE 49114 (1998); Ward, C.D. and Andreassen, E., *Pressure While Drilling Data Improves Reservoir Drilling Performance*, SPE 37588 (1997). Given the downhole pressure and the depth of the well, the operator can mathematically determine the “equivalent circulating density,” which is the effective density exerted by the drilling fluid against the formation. *Glossary of Oilfield Production Terminology*, American Petroleum Institute (1988).

By monitoring the downhole equivalent density, or more particularly, the difference between the downhole density and the surface density, the well operator can adjust the formulation of the drilling fluid to prevent the problems associated with too-low or too-high downhole density.[12] Further, as was discussed in §3.2.3, when circulation first begins, a non-Newtonian fluid such as drilling fluid will exhibit a yield point before it changes from a gel to a liquid. The time and force necessary to break the gel is indicated by the size and

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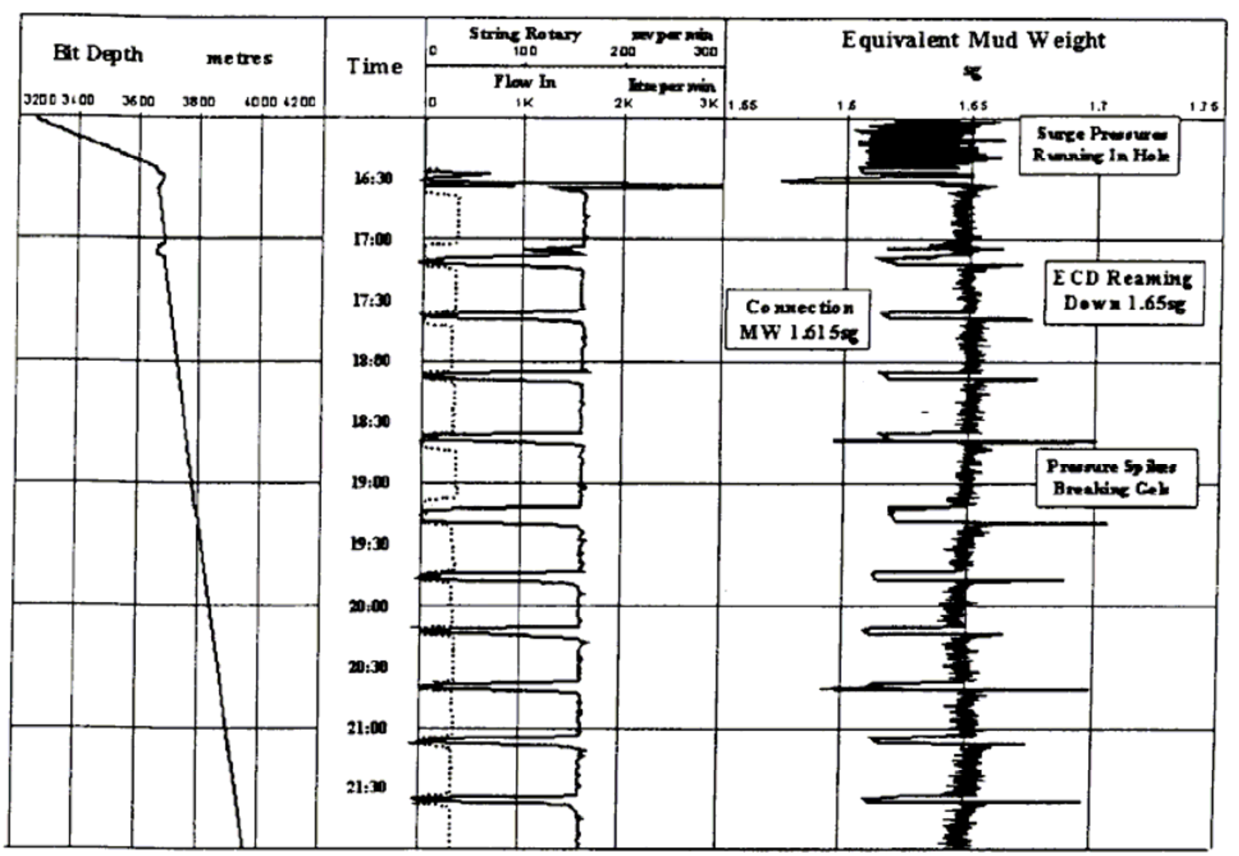
[12] Small differences between the equivalent circulating densities and the surface densities can be explained by the forces caused by the drill string movement, the rate of penetration (and associated volume of cuttings), and the flow of drilling fluid. Hutchison *et al., supra.* Large differences can be indicative of major failures in the performance of the drilling fluid. *Id.*

duration of the sudden surge in pressure as the circulation first begins. With the PWD information, the operator could take steps to optimize the drilling fluid's performance or to minimize the excessive pressure, for example, by restarting the drilling slowly. *E.g.,* Ward *et al., supra.* The figure below shows the correlation between restarting the drilling operation and the initial surge in downhole pressure.



3.4. Formulating Drilling Fluids

Based on the varied uses for drilling fluid, as discussed in §3.1 and the properties of drilling fluids, as discussed in §3.2, the optimum drilling fluid should have the following rheological characteristics:

- At very high flow rates, for example when fluid is flowing through the bit nozzles, the fluid should have very low viscosity.
- At high flow rates, for example, when the fluid is flowing through the drill string, the fluid should have a low viscosity so that undue pressure is not required to circulate the fluid.
- At slightly lower flow rates, for example when the surface equipment is removing the suspended solids, the fluid should be thin enough to maximize the separation of drilling solids from the fluid.
- At medium to low flow rates, for example as the fluid is moving upward through the annulus, the fluid should be sufficiently viscous to hold the cuttings and weighting material on the way to the surface, but not so viscous as to cause excessive pressure losses.
- At very low (or zero) flow rates, for example when the operator is adding pipe to the drill string and the fluid is stationary, it should be very viscous to prevent the cuttings and weighting material from settling.
- On restart after a period of rest, for example after the operator has added drill pipe to the drill string and resumed drilling, the fluid should not develop excessive gel strength which would require excessive pressure to initiate flow of the mud.

The geology of each oil well will differ from other wells in minor or major ways. Because of these differences, there is no such thing as a "universal" drilling fluid formulation that is perfect for every well and formation—the drilling fluid must be optimized for the particular geology of the well. Part of this optimization takes place prior to the commencement of drilling operations—based on the known characteristics of the formation and drilling conditions, the operator may choose a particular invert emulsion oil-based drilling fluid over a water-based fluid. However, another part of the optimization takes place at the well site—based on testing periodically performed on the drilling fluid properties and by monitoring downhole pressure readings, for example, the operator may modify the viscosity of the drilling fluid by introducing additives into the fluid at the surface and then relying on the circulation system to mix the additive into the fluid as it is pumped downhole. The following may be added to an oil-based drilling fluid by the service company representative in the field:[13]

- Weighting materials, including barite and hematite, may be used to increase the density of the mud in order to equilibrate the pressure between the wellbore and formation when drilling through particularly pressurized zones.

[13] The "mud engineer," who is usually an employee of the drilling fluids contractor, is responsible for building and maintaining the drilling fluid. The mud engineer tests the mud properties frequently and reports the results, along with appropriate recommendations, to the drilling supervisor. Other personnel on the platform may be employees of the drilling operator or other parties.

- Viscosity enhancing materials, including organophilic clays and polymeric fatty acids, may be used to increase the viscosity of the drilling fluid and minimize sag.
- Viscosity reducing materials (or "thinners"), including oligomeric fatty acids and polymer imide surfactants, may be used to reduce the viscosity of the drilling fluid. The base fluid may also be used to reduce viscosity caused by a buildup of drill solids.
- Filtration control materials, including organophilic leonardite (lignite) and asphalt, create a "cake" on the wall of the borehole which may help prevent seepage of the drilling fluid into the formation and may also improve borehole stability.
- Emulsifiers, including refined tall oil and polyaminated fatty acids increase the stability of the emulsion.
- pH control materials, such as lime, counter the effects of any naturally-occurring acid gases found in the wellbore and to activate emulsifiers.

Baroid Drilling Fluids, Ch. 13 (1997); Drilling Fluids, Encyclopedia of Chemical Technology, Vol. 18 (1996); Darley, H.C.H. and Gray, George R., *Composition and Properties of Drilling and Completion Fluids* 66-67, 561-562 (5th Ed. 1988).

4. Summary of the Patent

The inventions in the '832 patent teaches an oil- or synthetic-based invert emulsion drilling fluid which exhibits "fragile gel" behavior. '832 C1:L15-

L22, C2:L5-L8. As taught in the patent, a fragile gel, when used as a drilling fluid, will suspend drill cuttings and weighting material evenly throughout the fluid; however, as a drilling fluid, it must also have sufficient liquid characteristics so that it flows smoothly. ‘832 C2:L42-L57. The “fragileness” of the gel described in this patent comes from the fact that its characteristics can change from a gel to a liquid and back again, simply by the application or removal of stress: that is, the fragile gel liquefies or becomes less gel-like and more liquid-like under stress, such as caused by moving the fluid, but which quickly returns to a gel when the movement or other stress is removed, such as when circulation of the fluid is stopped, as for example when drilling is stopped. ‘832 C2:L26-L33. The various formulations of the fragile gels described in the patent are so “fragile” that they may be disrupted by a mere pressure wave or a compression wave during drilling: They seem to break instantaneously when disturbed, reversing from a gel back into a liquid form with minimum pressure, force and time and with less pressure, force and time than known to be required to convert prior art fluids from a gel-like state into a flowable state. ‘832 C2:L34-L42.

The summary also describes other attributes of the invention: The drilling fluid described in the patent responds quickly to the addition of thinners, it yields flatter profiles between cold water and downhole rheologies, it exhibits dramatically lower rates of drilling fluid loss into the formation, and is compliant with environmental regulations. ‘832 C2:L57-C3:L63. However, the drilling fluid contains little or no organophilic clays or organophilic lignites.

C3:L51-L64. According to the summary, this change represents a radical departure from traditional invert emulsion drilling fluids, and allows the drilling fluid described in the patent to have a greater tolerance for drill solids and perhaps contributes to the fluid's other superior performance characteristics as described in the patent, such as reducing or eliminating appreciable or noticeable pressure spikes and reducing or eliminating sag problems, which in turn lowers fluid losses. *Id.*

5. Expert Opinion as to the Meaning of Disputed Terms

I have reviewed the list of disputed terms provided to me by counsel for Halliburton, and I have analyzed each of the terms in the context of the patent claims, the specification, the drawings, and the prosecution history. As set forth in greater detail below, it is my opinion that none of the disputed terms are particular to the patent, and that a person of ordinary skill in the art would readily understand what is meant by the use of these terms in the patent claims. Further, I have reviewed the definitions proposed by Halliburton. As set forth in greater detail below, it is my opinion that the proposed definitions are consistent with the ordinary and accustomed meanings as understood by one of ordinary skill in the art at the time of the invention.

5.1. Fragile gel

As understood in the context of the patent claims, specification, and prosecution history, when considered in their entireties, a person of ordinary skill in the art would understand the term "fragile gel" to have the meaning as proposed by Halliburton:

> A fragile gel is a gel that easily transitions to a liquid state upon the introduction of force (e.g. when drilling starts) and returns to a gel when the force is removed (e.g. when drilling stops); the fragile gel, at rest, is capable of suspending drill cuttings and weighting materials. A fragile gel contains no organophilic clay or organophilic lignite or can contain low amounts of organophilic clay or lignite individually or in combination so that the fragile gel can still easily transition between a gel and liquid state and suspend drill cuttings and weighting materials.

I base my opinion on the following: For many years, well prior to the '832 patent, it was well understood by those of ordinary skill in the art that a superior drilling fluid would have strong gel characteristics but would quickly change to a liquid with a minimal force. In this context, the term "fragile gel" was sometimes used to describe this behavior of water-based drilling fluids as least as early as the 1970s. But while used to describe such drilling fluids, and generally thought to be a desirable characteristic, and while the term "fragile gel" was used occasionally to describe certain drilling fluid behavior, no quantitative or qualitative definition for the term "fragile gel" was ever adopted in the industry.[14]

Examining the patent claims against this backdrop, a person of ordinary skill would immediately find the term "fragile gel drilling fluid" in the preambles of four of the five independent claims, and necessarily in all of the dependent claims that derive from these claims. For example, claim 1 begins with "A

[14] For example, one article noted that with a particular fragile gel, the "gel structure developed over a relatively short period of time and did not continue to develop progressively." Friedheim, J.E. and Pantermuehl, R.M., *Superior Performance With Minimal Environmental Impact: A Novel Nonaqueous Drilling Fluid*, SPE 25753 (1993). Another article noted that a "fragile gel is a gel that is broken immediately and totally when a stress larger than the gel stress is reached." Saasen *et al., supra.*

method for conducting a drilling operation in a subterranean formation using a fragile gel drilling fluid comprising…" Outside of the context of the preamble, a person of ordinary skill would recognize the elements that follow the preamble as describing any of a number of prior art invert emulsion drilling fluids; however, when read in the context of the preamble, a person of ordinary skill would immediately understand the significance of an invert emulsion drilling fluid that exhibited fragile gel properties. Several of the dependent claims expressly teach the fragile gel properties: Claim 9[15] teaches that the claimed fragile gel drilling fluid is "capable of suspending drill cuttings at rest and that may be immediately disrupted by movement of said fluid," claim 10[16] teaches that the claimed fragile gel drilling fluid "reverts to a flowable or liquid state immediately upon resumption of drilling after a period of rest," and claim 20[17] teaches that the claimed fragile gel drilling fluid is "substantially free of organophilic clay." A person of ordinary skill in the art reading the patent claims would therefore understand that the term "fragile gel drilling fluid" would have the same meaning as proposed by Halliburton.

The specification also contains multiple references to the characteristics of a "fragile gel." Under the section "Summary of the Invention," at C2:L22-L57, the specification describes the properties of the fragile gel drilling fluid in terms that would be immediately recognized by a person of ordinary skill in the art as

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[15] Similarly in claims 42, 47, 80, 85, 117, and 121.
[16] Similarly in claims 48, 86, and 123.
[17] Similarly in claims 58, 95, and 125.

the characteristics of a superior drilling fluid, and would no doubt be surprised to find these characteristics in an invert emulsion drilling fluid. Similarly, a person of ordinary skill would understand tests and indicators typically used to measure the rheology of drilling fluids; that person would look at the rheological performance figures and graphs, as set forth in the figures (and accompanying text) and would recognize the reported figures and graphed curves as indicating the rheological characteristics of a fragile gel drilling fluid[18] as measured by commonly-used laboratory and field test equipment using well understood procedures. In addition, the specification emphasizes the importance of the organophilic material content of the fragile gel drilling fluid as set forth in the patent at Table 3, C3:L19-C3:L33, and C14:L1-C14:L10; this would leave one of ordinary skill in the art to conclude that the lack of organophilic material is a key feature of the claimed invention and part of what was intended by the term "fragile gel." Indeed, the lack of organophilic material is correctly described as a "radical departure" from the prior art drilling fluids, resulting in the unique and novel properties of the claimed invention. This is illustrated by the prior art systems set forth in the patent and related applications incorporated into the '832 patent by reference which contain significant amounts of organophilic material. Persons of ordinary skill in the art would recognize that the performance characteristics of these prior art systems are dissimilar from those that make the present invention

[18] That is, the rapid formation of strong gels accompanied by the rapid return to the fluid state with a minimal shear force. This translates roughly to the start/stop nature of drilling.

advantageous. As such, a person of ordinary skill in the art reading the patent specification would therefore understand that the term "fragile gel" would have the same meaning as proposed by Halliburton.

Additionally, I have reviewed the patent prosecution history for use of the term "fragile gel." I note that the inventors, in responding to the examiner's arguments that the claimed invention was anticipated by a number of prior art invert emulsions. 06/04/04 Office Action ¶¶4-8. In response, the applicants distinguished the claimed invention prior art by noting that none of the cited prior art invert emulsion drilling fluids exhibited fragile gel characteristics. 09/04/04 Response pp. 31-33. I found nothing in the prosecution history that would suggest any contrary meaning for the term, and so a person of ordinary skill, reading this response in the prosecution history, would again conclude that the term "fragile gel" as used in the patent claims would have the meaning as proposed by Halliburton.

Finally, as noted earlier in my report, I have searched for uses of the term "fragile gel" in numerous publications, and found multiple references using the terminology. Although these publications used the term in the context of drilling fluids, it is clear that the usage in these publications is consistent with the meaning as proposed by Halliburton.[19]

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[19] I note that M-I has asserted that this term is incapable of definition. I find this to be a curious position, given that one of the publications using the term "fragile gel" was in fact a publication of M-I.

5.2. Thinner

As understood in the context of the patent claims, specification, and prosecution history, when considered in their entireties, a person of ordinary skill in the art would understand the term "thinner" to have the meaning as proposed by Halliburton:

> A thinner is an additive that reduces viscosity.

I base my opinion on the following: In claim 1, one of the components of drilling fluid taught is "one or more thinners". C14:L21.[20] A person of ordinary skill in the art would recognize that in this context, this refers to a common additive of drilling fluids used to reduce its viscosity. *E.g., Baroid Drilling Fluids, Ch. 13 (1997); Drilling Fluids*, Encyclopedia of Chemical Technology, Vol. 18 (1996). Further, in claim 4, one of the components of the drilling fluid taught is "one or more thinners selected from the group consisting of…" C14:L55.[21] I recognize the compounds listed as coming from patent applications that were identified in the specification as PCT/US00/35609 and PCT/US00/35610; these applications that disclose the use of this group of compounds for reducing the viscosity of drilling fluids. Further, I note that in claim 12, an attribute of the "thinner" of claim 1 is that it "reduces the viscosity of said drilling fluid" in a particular manner.[22] A person of ordinary skill in the art reading the patent claims would therefore understand that the term "thinner" would have the same meaning as proposed by Halliburton.

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[20] Similarly in claims 2, 3, and 5.
[21] Similarly in claims 7, 41, 44, 79, 82, 116, 119, 120, and 148.

Additionally, the patent specification generally refers to "thinners" as something that would be added to drilling fluid to make it thinner (that is, less viscous). *E.g.,* C2:L64-C3:L4; C3:L50-L51; C9:L17-L21. The specification refers more particularly to materials described in two patent applications as being useful for "selective thinning" of drilling fluid. C9:L22-C10:L52. I have reviewed those applications and have found that the materials described are in fact materials used for reducing the viscosity of drilling fluids. The specification also refers to specific products sold under the trade names COLDTROL, OMC2, and ATC. C10:L52-L57. I have reviewed the product data sheets for these products and have found that the materials described are in fact materials used for reducing the viscosity of drilling fluids. Likewise, the specification also refers to a product sold under the trade name DEEP-TREAT, C11:L8-L9. I have reviewed the data sheet for this product and have found that this product is used as a wetting agent and thinner for drilling fluids. A person of ordinary skill in the art reading the patent specification would therefore understand that the term "thinner" would have the same meaning as proposed by Halliburton.

Additionally, I have reviewed the patent prosecution history for use of the term "thinner." I found nothing in the prosecution history that would suggest any contrary meaning for the term, and so a person of ordinary skill in the art reading the prosecution history would therefore understand that the term "thinner" would have the same meaning as proposed by Halliburton.

[22] Similarly in claims 50 and 88

Finally, I have consulted a technical reference book that would be readily available to and recognized as authoritative by a person of ordinary skill in the art, namely the *Glossary of Oilfield Production Terminology*. I found that Halliburton's proposed meaning for the term "thinner" is consistent with the meaning set forth in that reference book.

I understand that M-I has suggested that "thinner" should be limited to the two categories of thinners described in the patent as "selective thinners." In my opinion, a person of ordinary skill in the art would, upon reading the patent documents, recognize that these categories of thinners are examples of specific thinners optionally used for a particular purpose, namely selective thinning at specific temperature ranges. C9:L22-33. Nothing in the patent documents would have led a person of ordinary skill to believe that the plethora of thinners, available at the time and suitable for use with invert emulsion drilling fluids, would be off limits in synthesizing the claimed fragile gel drilling fluid.[23]

5.3. Immediately upon resumption of drilling

As understood in the context of the patent claims, specification, and prosecution history, when considered in their entireties, a person of ordinary skill in the art would understand the term "immediately upon resumption of drilling" to have the meaning as proposed by Halliburton:

> Immediately upon resumption of drilling means without substantial interval of time when drilling begins again after interruption.

[23] Provided of course that the thinner did not destroy the drilling fluid's fragile gel character.

I base my opinion on the following: Claim 10[24] use this term in the context of fragile gel behavior, as in “fragile gel reverts to a flowable or liquid state immediately upon resumption of drilling after a period of rest.” A person of ordinary skill in the art would understand that in this context, the “fragile gel” refers to the drilling fluid located within the entire length of the wellbore, and would understand that it is in the gel state because drilling has stopped.[25] A person of ordinary skill would also understand that the fundamental laws of physics and mechanics dictate that there will be some delay between the moment that the drilling operator restarts the drill string rotation and fluid circulation and the moment when the drilling fluid at any given point in the wellbore will revert to its liquid form. First, the drill string is not completely rigid—starting rotation of the top of the drill string may not start the rotation of the drill bit at the bottom of the drill string for several seconds, depending on, among other things, the type and length of the drill pipe. In addition, while the gels immediately adjacent to the drilling string may break when the string moves, it will take some finite amount of time for that movement to reach the gels further away from the drill string and closer to the walls of the annulus. Second, the force caused by the pump pushing drilling fluid into the top of the wellbore may not be felt by the drilling fluid at the bottom of the wellbore for several seconds, depending on, among other things, the density of the drilling fluid and the depth of the wellbore (the drilling fluid must flow all of the way

[24] Similarly in claims 48, 86, and 123.

[25] As noted earlier in this report, there are common interruptions to drilling, such as adding

through inside of the drill string to the bottom of the well and then flow back upward). A person of ordinary skill in the art reading the patent claims would understand that "immediately upon resumption of drilling" meant that the drilling fluid at any given depth would change from gel to liquid without any substantial delay after the force of the rotating drill string and/or circulating drilling fluid reached that given depth.

Additionally, the patent specification discusses this characteristic of the claimed invention. C2:L26-L57. It notes that the gels "may be disrupted by a mere pressure wave or a compression wave," "instantaneously when disturbed," "with minimum pressure, force and time and with less pressure, force and time than known to be required to convert prior art fluids from a gel-like state into a flowable state," and with "no appreciable or noticeable pressure spike … observed with pressure-while-drilling (PWD) equipment or instruments." A person of ordinary skill would understand that the claimed invention would convert the drilling fluid at any given depth when the pressure wave from the drilling fluid pump, traveling at the speed of sound, reached that depth. Further, the person of ordinary skill would know that in prior art drilling fluids, typically when the pressure wave reached the PWD equipment (near the bottom of the drill string), the conversion from gel to liquid would take enough time that the pressure increase would be detected by the equipment, but that with the claimed invention, the conversion would occur so

drill pipe to the drill string.

fast as to be barely registered (if at all) by the equipment. A person of ordinary skill in the art would, therefore, reading the specification would therefore understand that the term "immediately upon resumption of drilling" would have the same meaning as proposed by Halliburton.

Additionally, I have reviewed the patent prosecution history for use of the term "immediately upon resumption of drilling." I found nothing in the prosecution history that would suggest any contrary meaning for the term, and so a person of ordinary skill in the art reading the prosecution history would therefore understand that the term "immediately upon resumption of drilling" would have the same meaning as proposed by Halliburton.

I understand that M-I contends that the term "immediately upon resumption of drilling" should be construed as meaning "without interval of time." As I have noted, when drilling is resumed (that is, when the drill string rotation and drilling fluid circulation has started at the surface), it will take a non-zero amount of time for the forces to reach the bottom of the wellbore. The interpretation "without interval of time" does not account for this delay and is therefore an inferior definition in comparison to the meaning proposed by Halliburton.

5.4. Fragile gel behavior

As understood in the context of the patent claims, specification, and prosecution history, when considered in their entireties, a person of ordinary skill in the art would understand the term "fragile gel behavior" to have the meaning as proposed by Halliburton:

> Fragile gel behavior is immediately transitioning to a liquid state upon the introduction of force and immediately returning to a gel when the force is removed.

I base my opinion on interpretation of the claims, specification, prosecution history, and extrinsic evidence as set out in detail in §5.1.

5.5. Significant loss of drilling fluid

As understood in the context of the patent claims, specification, and prosecution history, when considered in their entireties, a person of ordinary skill in the art would understand the term "significant loss of drilling fluid" to have the meaning as proposed by Halliburton:

> Significant loss of drilling fluid means having drilling fluid losses that are 60% or more than that of a conventional drilling fluid.

I base my opinion on the following: Claim 21[26] uses this term in conjunction with a drilling operation, as in "said drilling is conducted without significant loss of drilling fluid." A person of ordinary skill in the art would understand that during the drilling process, some of the drilling fluid will be lost (a "seepage" loss) and that under unusual circumstances, all of the drilling fluid will be lost (a "total" loss). Based only on the claim language, a person of ordinary skill reading the patent claims would construe a "significant loss of drilling fluid" to be more than a seepage loss but less than a total loss.

The specification, however, provides clarification. In the Detailed Description of Preferred Embodiments, the specification notes that the claimed invention may be used "without significant loss of drilling fluid <u>when compared</u>

[26] Similarly in claims 59 and 96.

to drilling operations with prior art fluids." C4:L56-63 (emphasis added). The specification directs the reader to Figs. 1(a), 1(b), and 1(c), which show graphically how the claimed invention performed in terms of fluid loss as compared with a number of other prior art drilling fluids. Id. Reviewing Fig. 1(a), a person of ordinary skill in the art would recognize that in the drilling fluid of the claimed invention ("WELL H") experienced a loss of about 300 barrels of drilling fluid in comparison to the next best fluid ("WELL E") which experienced a loss of about 500 barrels. Or in other words, the claimed invention only lost about 60% of the amount of fluid in comparison with the best prior art drilling fluid. Thus, to a person of ordinary skill in the art reading the patent specification, any loss in excess of that amount would be a "significant loss of drilling fluid."

Additionally, I have reviewed the patent prosecution history for use of the term "significant loss of drilling fluid." I found nothing in the prosecution history that would suggest any contrary meaning for the term, and so a person of ordinary skill in the art reading the prosecution history would therefore understand that the term "significant loss of drilling fluid" would have the same meaning as proposed by Halliburton.

5.6. Maintains its viscosity

As understood in the context of the patent claims, specification, and prosecution history, when considered in their entireties, a person of ordinary skill in the art would understand the term "maintains its viscosity" to have the meaning as proposed by Halliburton:

> Maintains its viscosity at higher temperatures means viscosity does not substantially change at temperatures over about 120 degrees Fahrenheit.

I base my opinion on the following: Claim 51[27] uses this term in the context of describing the viscosity of the claimed drilling fluid at higher temperatures. A person of ordinary skill would understand that (a) viscosity may decrease as the temperature increases and (b) the temperatures up and down the drill string may vary dramatically; as such, a person of ordinary skill reading the patent claims would understand the viscosity would not decrease dramatically as the temperature increases (but a person of ordinary skill would not necessarily assign any temperatures ranges).

The specification, however, provides clarification by expressly stating that "'higher temperatures' means temperatures over about 120 degrees Fahrenheit. C3:L13-L15. Further, Table 2 (and accompanying text) provides the rheological data for the claimed invention as measured from 40 to 270 degrees Fahrenheit and indicate that the viscosity, while changing over that range, does not change substantially. Thus, to a person of ordinary skill in the art reading the patent specification, a drilling fluid that maintains its viscosity at high temperatures would exhibit viscosity changes in the same general range as indicated by Table 2.

Additionally, I have reviewed the patent prosecution history for use of the term "maintains its viscosity." I found nothing in the prosecution history that would suggest any contrary meaning for the term, and so a person of ordinary

skill in the art reading the prosecution history would therefore understand that the term "maintains its viscosity" would have the same meaning as proposed by Halliburton.

5.7. Conducting a drilling operation

As understood in the context of the patent claims, specification, and prosecution history, when considered in their entireties, a person of ordinary skill in the art would understand the term "conducting a drilling operation" to have the meaning as proposed by Halliburton:

> Conducting a drilling operation means directing or taking part in the operation or management of drilling, running casing and/or cementing.

I base my opinion on the following: Claim 1[28] uses this term in the context of "conducting a drilling operation in a subterranean formation using a fragile gel drilling fluid." A person of ordinary skill in the art would understand that this would include all of the steps taken during the process of drilling a well that involve the use of drilling fluid. As noted earlier in this report, drilling fluid is used in almost every phase of drilling a well, including the actual drilling as well as during the casing and cementing phases. Further, claim 1 expressly states that the operation "includes running casing in a borehole. Similarly, claims 45 and 46 expressly state that the operation includes "drilling a borehole" and "cementing a borehole." As such, a person of ordinary skill in the art reading the patent claims would understand that "conducting a drilling

[27] Similarly in claim 89.
[28] Similarly in claim 2.

operation" would include all tasks required to implement the drilling, casing, and cementing phases.

Additionally, the specification makes clear that the claimed invention relates to the use of drilling fluids for "drilling, cementing and casing boreholes in subterranean formations." C1:L15-L18. It also provides more detail on the uses of drilling fluids in the actual drilling phase: "The various functions of a drilling fluid include removing drill cuttings from the wellbore, cooling and lubricating the drill bit, aiding in support of the drill pipe and drill bit, and providing a hydrostatic head to maintain the integrity of the wellbore walls and prevent well blowouts." C1:L27-L32. Similarly, Figs. 1(a), 1(b), 1(c), and 2 (and accompanying text) compare the claimed invention against prior art fluid in terms of loss rate "incurred during drilling, running casing, and cementing." C3:L66-C4:L10; C4:L63-C5:L51. Similarly, the specification discusses the claimed invention's fragile gel behavior "in drilling operations, such as drilling, running casing, and cementing." C11:L57-L60. Finally, the abstract to the invention states that the patent discloses a method "for drilling, running casing in, and/or cementing a borehole in a subterranean formation." As such, a person of ordinary skill in the art reading the patent claims would understand that "conducting a drilling operation" would include all of the tasks associated with the drilling, casing, and cementing phases.

Additionally, I have reviewed the patent prosecution history for use of the term "conducting a drilling operation." I found nothing in the prosecution history that would suggest any contrary meaning for the term, and so a person

of ordinary skill in the art reading the prosecution history would therefore understand that the term "conducting a drilling operation" would have the same meaning as proposed by Halliburton.

5.8. Fragile gel drilling fluid

As understood in the context of the patent claims, specification, and prosecution history, when considered in their entireties, a person of ordinary skill in the art would understand the term "fragile gel behavior" to have the meaning as proposed by Halliburton:

> A fragile gel drilling fluid is a drilling fluid that easily transitions to a liquid state upon the introduction of force (e.g. when drilling starts) and returns to a gel when the force is removed (e.g. when drilling stops); the fragile gel drilling fluid, at rest, is capable of suspending drill cuttings and weighting materials. A fragile gel drilling fluid contains no organophilic clay or organophilic lignite or can contain low amounts of organophilic clay or lignite individually or in combination so that the fragile gel drilling fluid can still easily transition between a gel and liquid state and suspend drill cuttings and weighting materials.

I base my opinion on interpretation of the claims, specification, prosecution history, and extrinsic evidence as set out in detail in §5.1.

5.9. ECDs

As understood in the context of the patent claims, specification, and prosecution history, when considered in their entireties, a person of ordinary skill in the art would understand the term "ECDs" to have the meaning as proposed by Halliburton:

> ECD means the difference in the drilling fluid's measured surface density and the drilling fluid's equivalent circulating density downhole.

I base my opinion on the following: Claim 3[29] uses the term in the context of a measured value, as in "the ECDs are less than about 0.5." A person of ordinary skill in the art would understand that an ECD is roughly an acronym for "equivalent circulating density" A person of ordinary skill would recognize that an ECD of "about 0.5" would be a non-standard way to describe an ECD, and would look to the specification for clarification.

The specification brings the clarification by describing exactly what was intended by the claim language: "<u>This difference</u> in a drilling fluid's measured surface density at the well head and the drilling fluid's equivalent circulating density downhole (as typically measured during drilling by downhole pressure-while-drilling (PWD) equipment) is often called 'ECD' in the industry. Low 'ECDs', that is, a minimal difference in surface and downhole equivalent circulating densities, is critical in drilling deep water wells and other wells where the differences in subterranean formation pore pressures and fracture gradients are small." C6:L37-L47 (emphasis added). Further, Table 1, which compares the equivalent circulating density (measured downhole) and the mud weight at the well surface for the claimed invention and for a prior art drilling fluid; for the claimed invention, the differences are less than about 0.5, as taught by claims 3 and 16.

Further, I have reviewed the patent prosecution history for use of the term "ECDs." I found nothing in the prosecution history that would suggest

[29] Similarly in claim 16.

any contrary meaning for the term, and so a person of ordinary skill in the art reading the prosecution history would therefore understand that the term "ECDs" would have the same meaning as proposed by Halliburton.

5.10. Less than about 0.5

As understood in the context of the patent claims, specification, and prosecution history, when considered in their entireties, a person of ordinary skill in the art would understand the term "less than about 0.5" to have the meaning as proposed by Halliburton:

> Less than about 0.5 means constituting a more limited number than about 0.5.

I base my opinion on the following: Claim 3[30] uses this term to describe values for ECDs, which a person of ordinary skill in the art would understand to mean "equivalent circulation density," that ECDs are values that are mathematically-derived from measurements taken from multiple instruments, and that the accuracy of any mathematically-derived value will be subject to the accuracy of each of the components of the formula. *E.g.,* Pierce et al, Quantitative Analysis, 4th Ed. p. 123-28 (1958), and Daniels et al, *Experimental Physical Chemistry* (5th Ed.) 321-31 (1956). As such, in reading the claims, a person of ordinary skill in the art would understand the "less than about 0.5" to have the meaning as proposed by Halliburton.

In addition, Table 1 of the patent specification, for example, reports the ECDs of a product based on the claimed invention. The differences between

[30] Similarly in claim 16.

column 1 and column reflect values listed are less than about 0.5, given the accuracy of the numbers shown. As such, in reading the specification, a person of ordinary skill in the art would understand the "less than about 0.5" to have the meaning as proposed by Halliburton.

Further, I have reviewed the patent prosecution history for use of the term "less than about 0.5." I found nothing in the prosecution history that would suggest any contrary meaning for the term, and so a person of ordinary skill in the art reading the prosecution history would therefore understand that the term "less than about 0.5" would have the same meaning as proposed by Halliburton.

5.11. A structure

As understood in the context of the patent claims, specification, and prosecution history, when considered in their entireties, a person of ordinary skill in the art would understand the term "a structure" to have the meaning as proposed by Halliburton:

> A structure is an entity that has ordered interaction between chemicals and particles.

I base my opinion on the following: Claim 9[31] uses the term in the context of describing an attribute of a fragile gel, as in "said fragile gel is a structure that is capable of suspending drill cuttings at rest and that is instantaneously disruptible by movement." A person of ordinary skill in the art would understand that all molecules have some physical shape and internal

[31] Similarly in claims 57 and 85.

organization of atomic and subatomic particles, that molecules interact based on those characteristics, and that changes in energy can affect those characteristics (and necessarily the interactions between molecules). E.g., Brady, J.E. and Humiston, G.E., *General Chemistry*, 2nd Ed. 97-123 (1978). A person of ordinary skill, in reading the claims, would understand “a structure” to mean the physical shape and internal organization of the molecules of the drilling fluid, and how that physical shape and internal organization interacts with the physical shape and internal organization of other molecules of the drilling fluid as well the drill cuttings. Thus a person of ordinary skill in the art reading the claims would construe “a structure” to have the meaning proposed by Halliburton.

The specification refers to the “structure” of the fragile gel drilling fluid in terms of the way that it interacts with itself and with drill cuttings: “The significant reduction in mud loss seen with the present invention is believed to be due at least in substantial part to the fragile gel behavior of the fluid of the present invention and to the chemical structure of the fluid that contributes to, causes, or results in that fragile gel behavior. … [T]he structure of the drilling fluids of the invention, that is, the fragile gel structure, contributing to the fragile gel behavior results in lower surge and swab pressure.” C5:L30-L46. A person of ordinary skill in the art reading the specification would construe “a structure” to have the meaning proposed by Halliburton.

Further, I have reviewed the patent prosecution history for use of the term “a structure.” I found nothing in the prosecution history that would

suggest any contrary meaning for the term, and so a person of ordinary skill in the art reading the prosecution history would therefore understand that the term “a structure” would have the same meaning as proposed by Halliburton.

5.12. Immediately disrupted

As understood in the context of the patent claims, specification, and prosecution history, when considered in their entireties, a person of ordinary skill in the art would understand the term “immediately disrupted” to have the meaning as proposed by Halliburton:

> Immediately disrupted means broken apart without substantial interval of time.

I base my opinion on the following: Claim 9[32] uses this term in conjunction with describing the behavior of the claimed drilling fluid, as in “said fragile gel is a structure capable of suspending drill cuttings at rest and that may be immediately disrupted by movement of said fluid.” This usage is very similar to the usage of the disputed term “immediately upon resumption of drilling. As such, for the same reasons as set forth in §5.3, a person of ordinary skill in the art reading the patent claims, specification, and prosecution history would understand that the term “immediately disrupted” would have the same meaning as proposed by Halliburton.

5.13. No appreciable pressure spike

As understood in the context of the patent claims, specification, and prosecution history, when considered in their entireties, a person of ordinary

[32] Similarly in claims 47 and 85.

skill in the art would understand the term "no appreciable pressure spike" to have the meaning as proposed by Halliburton:

> No appreciable pressure spike is very low or no pressure measured upon resumption of fluid movement that could cause an adverse effect on a drilling operation.

I base my opinion on the following: Claim 11[33] uses the term in the context of the downhole pressure measured at the point when drilling is resumed, as in "no appreciable pressure spike is observed by pressure-while-drilling equipment when said drilling is resumed." As noted earlier in the report, drilling periodically stops for various reasons, for example, so that the operator can add drill pipe to the drill string. When this happens, the drill cuttings and weighting materials in the drilling fluid will have the tendency to settle downward—one of the functions of the drilling fluid is to hold the materials in suspension until drilling resumes, and it does so by transforming from a liquid to a gel strong enough to hold the materials in place. However, typically, the stronger the gel, the more difficult it is to break it up and transform it back into a liquid. When the drill string restarts its rotation and the drilling fluid pump resumes the circulation of fluid, downhole pressures will build up until the gels break; excessive pressures can fracture the formation. *See* Bloys, B.; Davis, N.; Smolen, B.; Bailey, L.; Houwen, O.; Reid, P.; Sherwood, J; Fraser, L; Hodder, M.; *Designing and Managing Drilling Fluid*, Oilfield Review (April 1994). Pressure-while-drilling equipment, located near the

[33] Similarly in claims 49, 87, and 128.

drill bit, will measure downhole pressures and send that information to the surface, where it can be monitored by the operator, who would recognize the sharp, momentary increase in the downhole pressure associated the breaking of the gel structures (or in the case of this claim, the absence of this sharp, momentary increase in pressure). Thus a person of ordinary skill in the art reading the claims would construe "no appreciable pressure spike" to have the meaning proposed by Halliburton.

In addition, the specification supports this interpretation when it contrasts the characteristics of the claimed invention with prior art: "[W]hen drilling is resumed, the fragile gel is so easily and instantly converted back into a liquid or flowable state that no initial appreciable or noticeable pressure spike is observed with pressure-while-drilling (PWD) equipment or instruments." C2:L52-L57. A person of ordinary skill in the art reading the specification would construe "no appreciable pressure spike" to have the meaning proposed by Halliburton.

Further, I have reviewed the patent prosecution history for use of the term "no appreciable pressure spike." I found nothing in the prosecution history that would suggest any contrary meaning for the term, and so a person of ordinary skill in the art reading the prosecution history would therefore understand that the term "no appreciable pressure spike" would have the same meaning as proposed by Halliburton.

5.14. Viscosity

As understood in the context of the patent claims, specification, and prosecution history, when considered in their entireties, a person of ordinary skill in the art would understand the term “viscosity” to have the meaning as proposed by Halliburton:

> Viscosity is a property of fluids indicating their resistance to flow.[34]

I base my opinion on the following: Claim 12[35] uses the term in the context of describing the effect that a thinner has on drilling fluids, as in “said thinner reduces the viscosity of said drilling fluid.” A person of ordinary skill in the art would understand that “viscosity” describes a fluid’s resistance to flow, and that thinners are typically used with drilling fluids to cause them to flow more readily. Thus a person of ordinary skill in the art reading the claims would construe “viscosity” to have the meaning proposed by Halliburton.

The specification confirms this meaning of “viscosity.” For example, the specification notes that “the drilling fluid of the invention suspends drill cuttings through its gel or gel-like characteristics, without need for organophilic clays to add viscosity to the fluid.” C2:L48-L51. A person of ordinary skill in the art would understand that organophilic clays are typically added to drilling fluids in order to make them more viscous. Similarly, Fig. 10 (and accompanying text) compares the “viscosity” of various base oils as a

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[34] I understand that M-I has proposed that viscosity be defined as “Resistance to flow defined as the ratio of shear stress to shear rate.” While this correctly states how viscosity is calculated, it doesn’t fully state what viscosity is, which is the “property of fluids indicating their resistance to flow.”

function of temperature. A person of ordinary skill in the art would understand that most fluids become less resistant to flow as the temperature increases, and this figure, plotting “viscosity” as a function of temperature, is consistent with that property. Further, the specification notes that the quantity of thinner added to a drilling fluid “is an effective amount to maintain or effect the desired viscosity of the drilling fluid.” C9:L47-L48. Again, a person of ordinary skill would understand that thinners are added to drilling fluids to make them less resistant to flow. Thus a person of ordinary skill in the art reading the specification would construe “viscosity” to have the meaning proposed by Halliburton.

Further, I have reviewed the patent prosecution history for use of the term “viscosity.” I found nothing in the prosecution history that would suggest any contrary meaning for the term, and so a person of ordinary skill in the art reading the prosecution history would therefore understand that the term “viscosity” would have the same meaning as proposed by Halliburton.

5.15. Lower yield point

It is my understanding that M-I has removed this term from its list of terms in need of interpretation by the court. As such, I have not formed an opinion as to how it would be understood by a person of ordinary skill in the art.

[35] Similarly in claims 50 and 88.

5.16. Equivalent circulating density

As understood in the context of the patent claims, specification, and prosecution history, when considered in their entireties, a person of ordinary skill in the art would understand the term “equivalent circulating density” to have the meaning as proposed by Halliburton:

> Equivalent circulating density means the pressure, as calculated in terms of density, exerted by the drilling fluid on the formation at any given point in the well while the fluid is circulating.

I base my opinion on the following: Claim 15[36] uses the term in comparing a property of the drilling fluid as measured downhole to that property as measured at the surface, as in “the equivalent circulating density of said drilling fluid approximates the surface density of said drilling fluid.” A person of ordinary skill in the art would understand that the equivalent circulating density is a number derived from a pressure reading taken downhole near the drill bit (using “pressure-while-drilling” equipment) and the depth of the wellbore. As such, a person of ordinary skill reading the claims would understand the term to have the meaning proposed by Halliburton. [37]

In addition, the specification indicates that this is the correct usage: “Such viscoelasticity, along with the fragile gel behavior, is believed to enable the fluid of the invention to minimize the difference in its density at the surface and its equivalent circulating density downhole. This difference in a drilling

[36] Similarly in claims 24, 53, and 92.

[37] This is slightly different from the definition of an “ECD” which, as noted 5.9 is expressed in terms of the difference between equivalent circulating density measured downhole and the surface pressure.

fluid's measured surface density at the well head and the drilling fluid's equivalent circulating density downhole (as typically measured during drilling by downhole pressure-while-drilling (PWD) equipment) is often called 'ECD' in the industry." C6:L33-L47. Further, Table 1 (and accompanying text) compares the equivalent circulating densities of the claimed invention and a prior art drilling fluid in terms of the pressure-while-drilling readings taken at a number of depths. Further, Figs. 5 (and accompanying text) graphically shows the equivalent circulating densities of the claimed invention and prior art drilling fluids under a variety of conditions, and Figs. 6 through 8 (and accompanying text) graphically show the equivalent circulating densities of the claimed invention under a variety of conditions. As such, a person of ordinary skill reading the specification would understand the term to have the meaning proposed by Halliburton.

Further, I have reviewed the patent prosecution history for use of the term "equivalent circulating density." I found nothing in the prosecution history that would suggest any contrary meaning for the term, and so a person of ordinary skill in the art reading the prosecution history would therefore understand that the term "equivalent circulating density" would have the same meaning as proposed by Halliburton.

5.17. Approximates the surface density

As understood in the context of the patent claims, specification, and prosecution history, when considered in their entireties, a person of ordinary

skill in the art would understand the term “approximates the surface density” to have the meaning as proposed by Halliburton:

> Approximates the surface density means to come near in value to the surface density.

I base my opinion on the following: Claim 15[38] uses the term in the context of a comparison with the equivalent circulating density. As noted earlier in my report, the equivalent circulating density is calculated by measuring the downhole pressure with equipment installed near the bottom of the drill string, and then mathematically converting that pressure to an equivalent density. A person of ordinary skill would recognize that while some difference is normal, if the equivalent circulating density was significantly different from the surface density, there could be an influx from the formation or insipient fluid losses into the formation that may indicate problems in the drilling fluid formulation, and in either case, immediate action could be warranted. As such, a person of ordinary skill reading the claims would understand the term to have the meaning proposed by Halliburton.

In addition, the specification indicates that this is the correct usage: “Such viscoelasticity, along with the fragile gel behavior, is believed to enable the fluid of the invention to minimize the difference in its density at the surface and its equivalent circulating density downhole.” C6:L33-L36. Further, Table 1 (and accompanying text) compares the equivalent circulating densities of the claimed invention to the surface density, and Figs. 6 through 8 (and

[38] Similarly in claims 53 and 92.

accompanying text) graphically show the equivalent circulating densities of the claimed invention compared to the surface densities. This shows that while the values are not identical, they are acceptably close. As such, a person of ordinary skill reading the specification would understand the term to have the meaning proposed by Halliburton.[39]

Further, I have reviewed the patent prosecution history for use of the term "approximates the surface density." I found nothing in the prosecution history that would suggest any contrary meaning for the term, and so a person of ordinary skill in the art reading the prosecution history would therefore understand that the term "approximates the surface density" would have the same meaning as proposed by Halliburton.

5.18. Equivalent circulating densities

As understood in the context of the patent claims, specification, and prosecution history, when considered in their entireties, a person of ordinary skill in the art would understand the term "equivalent circulating densities" to have the meaning as proposed by Halliburton:

> Equivalent circulating densities are pressures, as calculated in terms of density, exerted by the drilling fluid on the formation when the fluid is circulating.

I base my opinion on the following: Claim 23[40] use this term in the same context as other claim terms use the singular version of this term. A person of

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[39] I note that M-I has suggested surface density relates to the density at the wellhead. While this may be true for land-based or shallow water drilling, for a deep-water operation, the wellhead is located on the seafloor where a sample cannot be obtained.

[40] Similarly in claims 24, 61, and 98.

ordinary skill would have no reason to interpret this term any differently from "equivalent circulating density" other than the obvious singular versus plural difference. Refer to §5.16 for the basis of my opinion.

5.19. Incorporates said additives quickly

As understood in the context of the patent claims, specification, and prosecution history, when considered in their entireties, a person of ordinary skill in the art would understand the term "incorporates said additives quickly" to have the meaning as proposed by Halliburton:

> Incorporates said additives quickly means without need for multiple circulations of the fluid to show the effect of the addition.

I base my opinion on the following: Claim 40[41] uses this term in the context of the use of additives in drilling fluid, as in "said drilling fluid incorporates said additive or additives quickly." As noted earlier in this report, the drilling operator closely monitors the performance of the drilling fluid and the conditions of the downhole environment, and based on various indicators, may conclude that modifying the drilling fluid by introducing an additive will correct a problem or otherwise improve the efficiency of the drilling operation. Because of the serious consequences of failing to correct a problem (both in financial terms and in worker safety terms), the operator would want to get the modified drilling fluid to the trouble spot as soon as possible so that if necessary he could take additional steps to correct the problem. If multiple circulations were required to observe the effect of the additive, substantial time

[41] Similarly in claims 78 and 115.

would be lost and money expended.[42] An additive whose effect could be observed more quickly would mitigate the time and expense issues. As such, a person of ordinary skill reading the claims would that the term would mean, at a minimum, that the additives were incorporated into the fluid quickly enough that the results of the modification would be quickly apparent.

The specification quantifies this term: In discussing the addition of thinners, it states that the "drilling fluid of the invention responds quickly to the addition of thinners, with thinning of the fluid occurring soon after the thinners are added, without need for multiple circulations of the fluid with the thinners additive or additives in the wellbore to show the effect of the addition of the thinners." C2:L64-C3:L4. As such, a person of ordinary skill reading the specification would understand the term to have the meaning proposed by Halliburton

Further, I have reviewed the patent prosecution history for use of the term "incorporates said additives quickly." I found nothing in the prosecution history that would suggest any contrary meaning for the term, and so a person of ordinary skill in the art reading the prosecution history would therefore understand that the term "incorporates said additives quickly" would have the same meaning as proposed by Halliburton.

[42] For a deep well, a single circulation may take several hours, and if penetration must be stopped or slowed until the additive is fully incorporated, just one extra circulation cycle could add tens of thousands of dollars to the operating costs.

5.20. Instantaneously disruptible

As understood in the context of the patent claims, specification, and prosecution history, when considered in their entireties, a person of ordinary skill in the art would understand the term “instantaneously disruptible” to have the meaning as proposed by Halliburton:

> Instantaneously disruptible means able to be broken apart without any perceptible duration of time.

I base my opinion on the following: Claim 42[43] uses the term in the context of the fragile gel behavior of claimed drilling fluid, as in “said drilling fluid forms a structure that is capable of suspending drill cuttings at rest and that is instantaneously disruptible by movement.”

A person of ordinary skill in the art would understand that in this context, the drilling fluid is located within the entire length of the wellbore, and that it is in the gel state because drilling has stopped, and that while it is in the gel state, the drill cuttings are suspended in the gel. A person of ordinary skill would also understand that the fundamental laws of physics and mechanics dictate that there will be some delay between the moment that the drilling operator restarts the drill string rotation and fluid circulation and the moment when the drilling fluid at any given point in the wellbore will revert to its liquid form. Therefore, a person of ordinary skill in the art reading the patent claims would understand that “instantaneously disruptible” meant that the drilling fluid at any given depth would change from gel to liquid without any

[43] Similarly in claims 80, 117, and 121.

perceptible duration of time after the force of the rotating drill string and/or circulating drilling fluid reached that given depth.

Additionally, the patent specification discusses this characteristic of the claimed invention. C2:L26-L57. It notes that the gels “may be disrupted by a mere pressure wave or a compression wave,” “instantaneously when disturbed,” “with minimum pressure, force and time and with less pressure, force and time than known to be required to convert prior art fluids from a gel-like state into a flowable state,” and with “no appreciable or noticeable pressure spike … observed with pressure-while-drilling (PWD) equipment or instruments.” A person of ordinary skill would understand that the claimed invention would convert the drilling fluid at any given depth when the pressure wave from the drilling fluid pump reached that depth. Further, the person of ordinary skill would know that in prior art drilling fluids, typically when the pressure wave reached the PWD equipment (near the bottom of the drill string), the conversion from gel to liquid would take enough time that the pressure increase would be detected by the equipment, but that with the claimed invention, the conversion would occur so fast as to be barely registered (if at all) by the equipment. A person of ordinary skill in the art would, therefore, reading the specification would therefore understand that the term “instantaneously disruptible” would have the same meaning as proposed by Halliburton.

Additionally, I have reviewed the patent prosecution history for use of the term “instantaneously disruptible.” I found nothing in the prosecution history

that would suggest any contrary meaning for the term, and so a person of ordinary skill in the art reading the prosecution history would therefore understand that the term "instantaneously disruptible" would have the same meaning as proposed by Halliburton.

I understand that M-I contends that the term "instantaneously disruptible" should be construed as meaning "without interval of time." As I have noted, when drilling is resumed (that is, when the drill string rotation and drilling fluid circulation has started at the surface), it will take a non-zero amount of time for the forces to reach the bottom of the wellbore. The interpretation "without interval of time" does not account for this delay and is therefore an inferior definition in comparison to the meaning proposed by Halliburton.

5.21. Surface and downhole equivalent circulating densities

As understood in the context of the patent claims, specification, and prosecution history, when considered in their entireties, a person of ordinary skill in the art would understand the term "surface and downhole equivalent circulating densities" to have the meaning as proposed by Halliburton:

> Surface density means the density measured at the surface. Equivalent circulating densities means pressures, as calculated in terms of density, exerted by the drilling fluid on the formation when the fluid is circulating.

I base my opinion on the following: Claim 128 uses the term in the context of noting that in the claimed drilling fluid invention, there is a "low difference in surface and downhole equivalent circulating densities." A person of ordinary skill in the art would understand that the density of the fluid at the

surface is measured using the API standard procedure, and the equivalent circulating density is a number derived from a pressure reading taken downhole near the drill bit (using “pressure-while-drilling” equipment) and the depth of the wellbore. There will always be some difference between the density of the drilling fluid as measured at the surface and the density measured downhole, and the drilling operator will monitor this difference and take steps as necessary to minimize the difference. Thus, a person of ordinary skill reading the claims would understand the term to have the meaning proposed by Halliburton.

In addition, the specification indicates that this is the correct usage: “Such viscoelasticity, along with the fragile gel behavior, is believed to enable the fluid of the invention to minimize the difference in its density at the surface and its equivalent circulating density downhole.” *E.g.,* C6:L33-L36. Further, Table 1 (and accompanying text) compares the equivalent circulating densities of the claimed invention to the surface density, and Figs. 5 through 8 (and accompanying text) graphically show the equivalent circulating densities of the claimed invention compared to the surface densities. Thus, a person of ordinary skill reading the specification would understand the term to have the meaning proposed by Halliburton.

Further, I have reviewed the patent prosecution history for use of the term “surface and downhole equivalent circulating densities.” I found nothing in the prosecution history that would suggest any contrary meaning for the term, and so a person of ordinary skill in the art reading the prosecution

history would therefore understand that the term "surface and downhole equivalent circulating densities" would have the same meaning as proposed by Halliburton.

5.22. No significant sag

As understood in the context of the patent claims, specification, and prosecution history, when considered in their entireties, a person of ordinary skill in the art would understand the term "no significant sag" to have the meaning as proposed by Halliburton:

> No significant sag means no noticeable stratification or uneven distribution of weighting materials along the length of the borehole in the drilling fluid at rest in a deviated borehole.

I base my opinion on the following: Claim 128 uses the term in the context of describing an attribute of drilling fluid, as in "said drilling fluid has … no significant sag." As noted earlier in this report, "sag" refers to a condition in high-angle and deviated wells where the weighting materials added to the drilling fluid will settle on the low side of the wellbore. This uneven distribution will be evidenced by the uneven densities in the return flow of the drilling fluid and by pressure spikes reported by the pressure-while-drilling equipment downhole. A consistency in the density of the return flow of fluids and the absence of pressure spikes would suggest that there is no significant sag. As such, a person of ordinary skill reading the claims would understand the term to have the meaning proposed by Halliburton.

In addition, the specification indicates that this is the correct usage: "When drilling is stopped while using a drilling fluid of the present invention,

and consequently the stresses or forces associated with drilling are substantially reduced or removed, the drilling fluid forms a gel structure that allows it to suspend drill cuttings and weighting materials for delivery to the well surface. The drilling fluid of the invention suspends drill cuttings through its gel or gel-like characteristics, without need for organophilic clays to add viscosity to the fluid. As a result, sag problems do not occur. Nevertheless, when drilling is resumed, the fragile gel is so easily and instantly converted back into a liquid or flowable state that no initial appreciable or noticeable pressure spike is observed with pressure-while-drilling (PWD) equipment or instruments." C2:L43-L57. As such, a person of ordinary skill reading the specification would understand the term to have the meaning proposed by Halliburton

Further, I have reviewed the patent prosecution history for use of the term "no significant sag." I found nothing in the prosecution history that would suggest any contrary meaning for the term, and so a person of ordinary skill in the art reading the prosecution history would therefore understand that the term "no significant sag" would have the same meaning as proposed by Halliburton.

5.23. Generally flat rheology

As understood in the context of the patent claims, specification, and prosecution history, when considered in their entireties, a person of ordinary skill in the art would understand "generally flat rheology" to have the meaning as proposed by Halliburton:

> Generally flat rheology means there is no significant difference in the rheology of the fluid at two different temperatures (e.g., 40 and 120 degrees Fahrenheit).

I base my opinion on the following: Claim 128 uses the term in the context of describing an attribute of drilling fluid as measured over a range of temperatures, as in "said drilling fluid has … generally flat rheology between higher and lower temperatures." As noted earlier in this report, a fluid may exhibit small or large changes in its yield point over a range of temperatures. Given the range of temperatures often found in a deep water well, a desirable attribute of a drilling fluid is that its yield point will not vary drastically over the range of temperatures commonly found along the length of the drill string. A drilling fluid's yield point may be expressed in terms of the appearance of a graph of its yield point as a function of temperature. As such, a person of ordinary skill reading the claims would understand the term to have the meaning proposed by Halliburton.

In addition, the specification indicates that this is the correct usage: "The drilling fluid of the invention also yields flatter profiles between cold water and downhole rheologies, making the fluid advantageous for use in deep water wells. That is, the fluid may be thinned at cold temperatures without causing the fluid to be comparably thinned at higher temperatures." C3:L4-L9. Table 2 (and accompanying text) shows the rheology of the claimed invention as measured by a Fann 75 viscometer, and indicates that the instrument dial readings at low speeds (6 and 3 RPMs) and the yields points were similar between 40 and 120 degrees (given a fixed pressure). The specification also lists

under “Other Publications” an article entitled “Flat Rheology SBM Shows Promise in Deepwater," which I have read and understand to be using the term “flat rheology” in a similar fashion as is used in the specification. *See* Power, D., Friedheim, J, and Toups, B.; *Flat Rheology SBM Shows Promise in Deepwater, Drilling Contractor* (May/June 2003). As such, a person of ordinary skill reading the specification would understand the term to have the meaning proposed by Halliburton

Further, I have reviewed the patent prosecution history for use of the term “generally flat rheology.” I found nothing in the prosecution history that would suggest any contrary meaning for the term, and so a person of ordinary skill in the art reading the prosecution history would therefore understand that the term “generally flat rheology” would have the same meaning as proposed by Halliburton.

6. Opinions as to Enablement

It is my understanding that the legal test for enablement is whether or not one of ordinary skill in the art could make or use the invention from the disclosures in the patent coupled with information known in the art without undue experimentation, and that a patent need not teach, and preferably omits, what is well known in the art. I have been further advised that there are many factors to be considered in determining whether or not any experimentation is “undue,” including but not limited to:

- The breadth of the claims;
- The nature of the invention;

- The state of the prior art;
- The level of one of ordinary skill;
- The level of predictability in the art;
- The amount of direction provided by the inventor;
- The existence of working examples; and
- The quantity of experimentation needed to make or use the invention based on the content of the disclosure.

In this case, the question is whether or not one of ordinary skill in the art could determine without undue experimentation if a drilling fluid is a fragile gel drilling fluid as claimed in the patent. Specifically, is the Brookfield test described in the patent and the results depicted in Figs. 3 and 4, enabled?

Beginning with review of the specification, Fig. 3 is described as a "graph indicating gel formation in fluids of the present invention and their response when disrupted compared to some prior art isomerized olefin fluids." C4:L11-L14. With reference to Fig. 3, one of ordinary skill in the art, by studying the graph along with the descriptive text in the specification, *e.g.,* C5:L53-C6:L15, would note the following:

- The test was performed with a Brookfield viscometer measuring torque versus time at a temperature of 120 degrees.
- During the performance of the test, the fluid was alternately stirred and allowed to come to rest for increasing lengths of time.
- After the respective rest periods, the shear stress was resumed by rotating the viscometer spindle or vane, and the torque response

measured as a function of time. The torque values in Fig. 3 are expressed as percentages rather than some defined rheological parameter because the attribute being measured is the shape of the response curve.

- The Accolade fluids tested exhibited the characteristic “L”-shaped response curves showing high peak torques and dramatic declines to their liquid-state torque levels, indicating strong gels (high torque) that break quickly to a low-viscosity liquid (low torque).
- In contrast, the SF fluids tested exhibited response curves showing much lower peak torques and less dramatic declines, indicating weaker gels.

Although the spindle geometry is not disclosed, one of ordinary skill in the art would know that a vane geometry was used based on the nature of the subject fluids, specifically, the fluids are described as fragile gels that break quickly and easily. In other words, these fluids have a low shear properties for which the Brookfield viscometer, fitted with a vane, would provide superior results such as those shown in Fig. 3. Additionally, one of ordinary skill in the art could easily determine by testing that a spindle geometry without vanes would not provide satisfactory torque response. This would be evident from the initial test run with a spindle without vanes.

The methodology and parameters for the test are disclosed except for the speed (RPM) at which the vane was rotated in the fluid samples. One of ordinary skill in the art would know to start using the speeds set forth by the

API standards; by methodically testing at different speeds, one would quickly find the optimum vane speeds. Once the optimum test speeds were established, all subsequent testing would use these speeds to ensure consistent results.

Further, Fig. 4 is described by the specification as showing a "graph of the relaxation rates of various drilling fluids, including fluids of the present invention and prior art isomerized olefin based fluids." C6:L18-L21. The specification describes the test procedure as follows: "In the test, conducted at 120 degrees Fahrenheit, the fluids are exposed to stress and then the stress is removed. The time required for the fluids to relax or to return to their pre-stressed state is recorded." A person of ordinary skill in the art would recognize this as a standard relaxation test. *E.g.,* Bloodworth *et al., supra*. The specification also notes that the "curves for the fluids of the invention seem to level out over time whereas the prior art fluids continue to decline." C6:L24-L26. The leveling out of the curves indicate that the fluids are returning to their pre-stressed state, that is, a fragile gel. One of ordinary skill in the art could confirm this assertion by observing that indeed, the shapes of the curves shown in Fig. 4 show torque measurements that fall and level off more quickly for the claimed invention than for the prior art fluids which do not.

Thus, by studying Figs. 3 and 4, and the accompanying text in the specification, one of ordinary skill in the art would be enabled to distinguish the "fragile gel drilling fluids" of the claimed invention from the prior art. In particular, the figures demonstrate that: the gels in the claimed invention

formed faster than those in the prior art fluids; the gels formed in the claimed invention are stronger than those formed in the prior art fluids; and upon application of stress, the gels in the claimed invention broke apart faster than those in the prior art fluids.

Further, beginning with the base formulation in Table 3, and the disclosure appearing thereafter, one skilled in the art could make the claimed drilling fluid and measure the fragility of its gels. This fluid would have no organophilic material. However, as every drilling operation is, to some extent, an exercise in experimentation, if and when it was thought to be beneficial, one of ordinary skill could determine the maximum amount of organophilic material (clay and/or lignite) that a drilling fluid could contain and still be a fragile gel drilling fluid. By adding organophilic clay or organophilic lignite (both contain a quaternary amine carbon chain), alone or in combination, and by observing the indicators comparable to those described in the patent, one of ordinary skill could confirm the presence of a fragile gel drilling fluid as defined follows: In the laboratory, one could use standard viscometer test equipment such as the Brookfield DV-II+ to measure the formation of the gels, the strength of the gels, and the time and force necessary to break the gels, through a series of tests at 10 seconds, 10 minutes, and 30 minutes, as well as the relaxation test, as taught by the patent. A person of ordinary skill would know that for the purpose of this test, it is the shape of the Brookfield test curve and not the instrument's absolute numeric results that is important. Thus, for a fragile gel, the test results, expressed as torque and plotted as a

function of time, would take the characteristic "L" shaped curve (comparable to the Accolade curves shown in Fig. 3), indicating a strong gel (high torque) that breaks quickly to a low-viscosity liquid (low torque). For a non-fragile gel, the decline in torque following the peak would be more gradual, and the difference between the peak and the final torque would be less dramatic (comparable to the 15.6 SF curve shown in Fig. 3). It would be well within the competence of a person of ordinary skill to expand the time scale of the graph to examine in more detail the torque response of the subject drilling fluid as a function of time. Similarly, using the same samples and instrumentation, one of ordinary skill could perform a relaxation test. For a drilling fluid of the claimed invention, the shape of the curve plotting torque against time would reflect that the fluid quickly returned to the pre-stress level and did not decrease further with the passage of time. For a drilling fluid not meeting the requirements of the claimed invention, the shape of the curve plotting torque against time would reflect that the fluid did not quickly return to the pre-stress level and continued to decrease further with the passage of time.

Alternatively or additionally, at the well site, one could use pressure-while-drilling equipment to observe the pressure, ECD, and sag data in the well, when using the mud with no organophilic material, and then add incremental amounts of organophilic material and observe the same measurements. When pressure spikes, sag, high ECDs, and/or increases in fluid loss begin to occur, one of ordinary skill in the art would recognize that such measurements indicate that the drilling fluid is no longer a fragile gel;

that is, it would no longer, for example, transition easily and quickly into a fluid upon resumption of drilling.

7. Conclusions

Based on my years of experience, my understanding of the rules of claim construction, and my reading of the claims, specification, and prosecution history of the '832 patent, and for the reasons set forth above, it is my expert opinion that the claim construction asserted by Halliburton is correct. It is my further opinion that a "person of ordinary skill in the art" would have the qualifications as set forth above. It is my further opinion that the '832 patent sets forth the claimed invention in sufficient detail such that a person of ordinary skill in the art could make and use the claimed invention based solely on the patent claims and specification, using only his or her ordinary skills in the art, and without undue experimentation.

Ronald K. Clark 3/17/06

Ronald K. Clark Date

Exhibit A—Curriculum Vitae

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Education

B.A. - Chemistry, University of California at Riverside, 1963

Ph.D. - Physical Chemistry, University of California at Riverside, 1966

Postdoctoral Research - Cornell University, 1966/67

Employment

Shell E&P Technology Company (formerly Shell Development Company) - 10/67 to 9/96

Enhanced Oil Recovery research - 10/67 to 3/71

Drilling Fluids research - 3/71 to 9/96

Retired as Senior Staff Research Chemist - 9/96

RK Clark Fluid Technology - 10/96 to present

Consulted for Dresser Industries (Dublin, Ireland), Halliburton (Denver), Newpark Drilling Fluids (Houston), Q'Max Solutions (Calgary), Shell E&P Technology Company (Houston), Sperry-Sun Drilling Services (Houston), Sonat Exploration (Houston), BP Amoco (Seattle, Houston), TXI Energy Services (Houston)

Expert Witness Experience

671905 Alberta Inc. and M-I Drilling Fluids Canada Inc. v. Q'Max Solutions Inc. (Court No. T-1227-96, Federal Court - Trial Division, Calgary, Alberta). Expert testimony for the defendant Q'Max Solutions Inc.

Professional Memberships

Sigma Xi

Society of Petroleum Engineers

American Chemical Society

Technical Society Activity/Positions

API Committee 13 - Standardization of Drilling Fluid Materials

Shell Alternate Voting Member - 1975 to 1984
Shell Voting Member - 1985 to 1995
Committee Vice Chairman - 1984 to 1986
Committee Chairman - 1987 to 1990

American Association of Drilling Engineers - Houston Chapter

Vice President - 1994/95
President - 1995/96
Board of Directors - 1996/97

SPE Drilling Program Committee

Member - 1986 to 1988
Chairman - 1988

Chairman - SPE Forum on Drilling and Completion Fluids - 1985

Cochairman - SPE Forum on Advances in Drilling Fluid Technology - 1994

Tulsa University Drilling Research Projects Advisory Board - 1979 to 1995

Publications

J. E. Fontenot and R. K. Clark, "An Improved Method for Calculating Swab and Surge Pressures and Circulating Pressures in a Drilling Well," Society of Petroleum Engineers Journal, October 1974.

R. K. Clark and J. E. Fontenot, "Field Measurements of the Effects of Drillstring Velocity, Pump Speed and Lost Circulation Material on Downhole Pressures," SPE 4970, presented at the 49th SPE Annual Fall Meeting, Houston, TX October 6-9, 1974.

R. K. Clark, R. F. Scheuerman, H. Rath, and H. G. van Laar, “Polyacrylamide/Potassium Chloride Mud for Drilling Water-Sensitive Shales,” Journal of Petroleum Technology, June, 1976.

R. L. Garrett, R. K. Clark, L. L. Carney, and C. K. Grantham, “Chemical Scavengers for Sulfides in Water-Base Drilling Fluids,” Journal of Petroleum Technology, June 1979.

R. K. Clark and J. J Nahm, “Petroleum Drilling Fluids,” Kirk-Othmer: Encyclopedia of Chemical Technology, 3rd Edition, Volume 17 pp. 143-167, 1982.

R. K. Clark, “Applications of Water-Soluble Polymers as Shale Stabilizers in Drilling Fluids,” Chapter 10 in Water-Soluble Polymers, American Chemical Society, Volume 213, Advances in Chemistry Series, 1986.

R. K. Clark and S. G. Almquist, “Evaluation of Spotting Fluids in a Full-Scale Differential Pressure Sticking Apparatus,” SPE Drilling and Completion, June 1992.

T. Hemphill and R. K. Clark, “Effects of PDC-Bit Selection and Mud Chemistry on Drilling Rates in Shale,” SPE Drilling and Completion, September 1994.

R. K. Clark and K. L. Bickham, “A Mechanistic Model for Cuttings Transport,” SPE 28306, presented at the 69th Annual Technical Conference and Exhibition, New Orleans, LA, September 25-28, 1994.

R. K. Clark, “Impact of Environmental Regulations on Drilling Fluid Technology,” Journal of Petroleum Technology, September 1994 (presented by invitation at the 1994 University of Tulsa Petroleum Engineering Symposium).

R. K. Clark, “Petroleum Drilling Fluids,” Kirk-Othmer; Encyclopedia of Chemical Technology, 4th Edition, Volume 18, pp. 370-405, 1996.

C. Ward and R. K. Clark, “Anatomy of a Ballooning Borehole Using PWD”, presented at the “Overpressures in Petroleum Exploration” workshop, Pau, France, April 7-8, 1998.

Exhibit B—Materials Provided by Counsel for Halliburton for Use and Review in Preparation of this Report

1. Bailey, L; Meeten, G; Way, P; L'Ailoret, F; *Filtercake Integrity and Reservoir Damage* (SPE 39429).
2. Bern, P.A.; van Oort, E.; Neusstadt, B; Ebeltoft, H; Zurdo, C.; Zamora, M.; Slater, K.; *Barite Sag: Measurement, Modeling and Management* (SPE 47784)
3. Bern, P.A; van Oort, E.; Neustadt, B.; Ebeltoft, H.; Zurdo, C.; Zamora, M; Slater, K.S.; *Barite Sag: Measurement, Modeling, and Management* (SPE 62051).
4. Bloodworth, B.R.; Keely, G.J.; Clark, P.E.; *Mud Relaxation Measurements Help Predict Hole Cleaning Ability*, Oil & Gas Journal (June 1, 1992).
5. Bloys, B.; Davis, N.; Smolen, B.; Bailey, L.; Houwen, O.; Reid, P.; Sherwood, J; Fraser, L; Hodder, M.; *Designing and Managing Drilling Fluid*, Oilfield Review (April 1994).
6. Brookfield Engineering Laboratories, *Brookfield DV-II+ Programmable Viscometer Operating Instructions.*
7. Brookfield Engineering Laboratories, *Brookfield SSV Vane Standard Spindle Set Assembly & Operating Instructions.*
8. Brookfield Engineering Laboratories, *More Solutions to Sticky Problems*, p. 2-3 (2004).
9. Carbajal, David; Transcript of Deposition (January 12, 2006).
10. Clark, R.K.; Scheuerman, R.F.; Hath, H.; Van Laar, H.G.; *Polyacrylamide/ Potassium-Chloride Mud for Drilling Water-Sensitive Shales* (SPE 5514).
11. Defendant M-I LLC's List of Disputed Claim Terms (November 21, 2005).
12. Defendant M-I LLC's Motion for Summary Judgment of Invalidity with Respect to U.S. Patent No. 6,887,832 (January 13, 2006).
13. Fraser, L.J.; Reid, P.I.; Williamson, L.D.; Enriquez, F.P.; *Formation-Damaging Characteristics of Mixed Metal Hydroxide Drill-In Fluids and a Comparison With Polymer-Base Fluids* (SPE 57714)
14. Friedheim, J.E.; Conn, H.L.; *Second Generation Synthetic Fluids in the North Sea: Are They Better?* (SPE 35061)
15. Frledheim, J.E.; Pantermuehl, R.M.; *Superior Performance With Minimal Environmental Impact: A Novel Nonaqueous Drilling Fluid* (SPE 25753).
16. Halliburton Baroid, *ATC, COLDTROL, OMC2, and DEEP-TREAT Product Data Sheets* (2004).
17. Hands, N.; Francis, P.; Whittle, A.; Rajasingam, D.; *Optimising Inflow Performance of a Long Multi-Lateral Offshore Well in Low Permeability, Gas Bearing Sandstone: K14-FB 102 Case Study* (SPE 50394)

18. Hands, N.; Kowbel, K.; Maikranz, S.; Nouris, R.; *Drill-In Fluid Reduces Formation Damage, Increases Production Rates*, Oil & Gas Journal (July 13, 1998).
19. Joint Claim Construction and Prehearing Statement Pursuant to P.R. 4-3 (January 20, 2006).
20. Neff, J.M.; McKelvie, S.; Ayers, R.C.; *Environmental Impacts of Synthetic Based Drilling Fluids* (2000).
21. Plaintiff's Preliminary Claim Constructions Pursuant to Local Patent Rule 4-2 (December 23, 2005).
22. Plank, J.P., *Water-Based Muds Using Synthetic Polymers Developed for High Temperature Drilling*, Oil & Gas Journal (March 2, 1992).
23. Power, D.; Friedheim J.; Toups, B; *Flat Fheology SBM Shows Promise in Deepwater*, Drilling Contractor (May-June 2003).
24. Reid, P.I.; Minton, R.C.; Twynam, A.; *Field Evaluation of a Novel Inhibitive Water-Based Drilling Fluid for Tertiary Shales* (SPE 24979).
25. Robinson, G.; Jachnik; R.P.; *Novel Viscometer for Improved Drilling Fluid Characterization* (1996)
26. Saasen, A.; Marken, C.; Sterri, N.; Jakobsen, J.; *Monitoring of Barite Sag Important in Deviated Drilling*, Oil & Gas Journal (August 26, 1991).
27. Samuels, A.; *H_2S Need Not Be Deadly, Dangerous, Destructive* (SPE 5202)
28. Servais, C.; Ranc, H.; Sansonnens, C.; Ravji, S.; Romoscanu, A.; Burbidge, A.; *Rheological Methods for Multiphase Materials* (2003)
29. Siems, Don; Rough Transcript of Deposition (December 12, 2005).
30. Solomons, T.W.G.; Organic Chemistry, 2nd Ed., p. 114-15 (1980).
31. USPTO, Non-Final Office Action on Application No. 10/175,272 (June 6, 2004).
32. White, W.; McLean, A.; *Better Practices and Synthetic Fluid Improve Drilling Rates*; Oil & Gas Journal (February 20, 1995).
33. Xiao, L.: Piatti, C.; Giacca, D.; Bartosek, M.; Nicula, S.; Gallino, G.; *Studies on the Damage Induced by Drilling Fluids in Limestone Cores* (SPE 50711).